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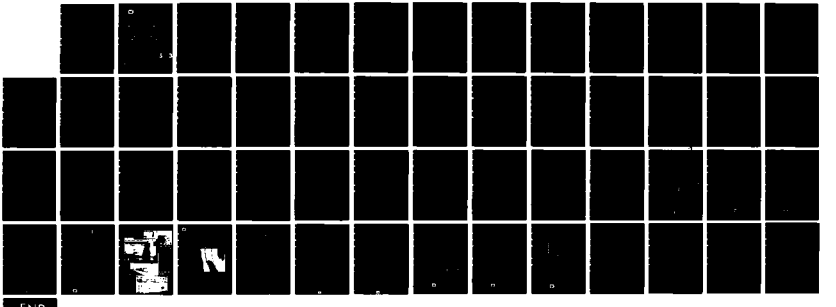

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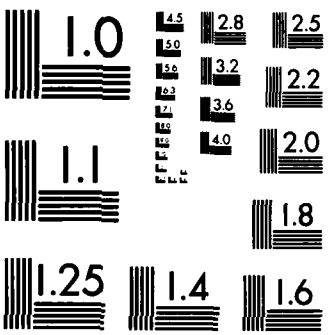

US Army Corps
of Engineers
St. Paul District

WINNIBIGOSHISH DAM

MISSISSIPPI RIVER, MINNESOTA

RECONNAISSANCE REPORT FOR
DAM SAFETY ASSURANCE PROGRAM

MARCH 1985

Unclassified

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WINNIBIGOSHISH DAM (MINNESOTA)

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This reconnaissance report evaluates the Winnibigoshish Dam and Lake project for potential safety hazards using current standards and state of the art.

Winnibigoshish Dam is located on the Mississippi River in north central Minnesota, 1247.9 river miles above the mouth of the Ohio River. The Dam is at the outlet of Winnibigoshish Lake, at the southeast end of the Lake, about 14 miles northwest of Deer River, Minnesota, in Leech Reservation in the southwest portion of Itasca County.

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The four primary features of the dam are: (1) an embankment of riprap, concrete and grout protecting a timber diaphragm, with puddled clay core: (2) a non air entrained reinforced concrete control structure: (3) a concrete spillway apron; and (4) a series of four dikes providing flood protection to sites near the Lake eight miles from the main dam.

WINNIBIGOSHISH DAM AND LAKE
MISSISSIPPI RIVER, MINNESOTA

RECONNAISSANCE REPORT

FOR

DAM SAFETY ASSURANCE PROGRAM

MARCH 1985

St. Paul District, Corps of Engineers
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

INTRODUCTION

1. This reconnaissance report evaluates the Winnibigoshish Dam and Lake project for potential safety hazards using current standards and state of the art. This report follows the regulations and format provided in ER 1130-2-417, Major Rehabilitation Program and Dam Safety Assurance Program. The Dam Failure Planning Report for Winnibigoshish Dam which addresses the consequences of not performing the recommended repair work, describes potential flood conditions downstream in the event of dam failure.

PROJECT AUTHORIZATION

2. In April 1870, a report was submitted showing that although the Mississippi River above the mouth of the Wisconsin River experiences a wide range of streamflows, regulation of water could be achieved by building a series of dams at the headwaters. These reservoirs could store spring runoff waters and releases of these waters could be made during periods of low-water, giving depth to the Mississippi River. In June 1878, Congress approved and ordered the examination and survey of the Mississippi River headwaters to determine the practicability of establishing such reservoirs, the cost of constructing and maintaining them, the amount of damage to private property therefrom, and the extent to which the impounded waters could be applied to the improvement of navigation of the Mississippi River. Congress authorized the construction of Winnibigoshish Dam as a test or pilot dam and construction was commenced during the winter of 1881-82. According to House Executive Document No. 54, 1879, Winnibigoshish Dam was found originally practicable at the efflux from Lake Winnibigoshish, 14 feet high, 1,114 feet long, and at the estimated cost of $59,969.80. The dam was placed in operation in 1886.

3. The project, as authorized by Congress, was funded through legislation of the River and Harbor Act of 1880.

PROJECT HISTORY

4. As late as the 1880's navigation on the Mississippi River, from the mouth of the Wisconsin River at Prairie du Chien, Wisconsin, to St. Paul, Minnesota, was considered hazardous. In 1896, Major General G.K. Warren headed a survey of the Mississippi Headwaters region in an effort to determine whether the river level along the 200 mile stretch between St. Paul and Prairie du Chien might not be stabilized. Four years after Major General Warren began his study, he reported that a system of dams and reservoirs on the headwaters of the Mississippi, St. Croix, Chippewa and Wisconsin Rivers would be capable of storing the annual spring runoff until low water downstream made it necessary to release the stored water, to achieve a desired river level and flow stabilization between St. Paul and Prairie du Chien.

5. This effort by Major General Warren prompted Congress to fund the Mississippi Headwaters project on June 14, 1880, through legislation of the River and Harbor Act of 1880. The six impounding structures and resulting reservoirs were authorized for construction to improve navigation on the Mississippi River by providing supplemental water during periods of low flow at and below Minneapolis and St. Paul, Minnesota. Construction on a test dam began in the winter of 1881 at Lake Winnibigoshish, and subsequent construction of dam facilities at Pokegama Lake, Leech Lake, the Pine River at Cross Lake, and Big Sandy Lake was completed by 1891. The sixth and final dam was built in the spring of 1911 at Gull Lake.

6. Original construction of Winnibigoshish Dam was started in 1882 and completed in 1891. The initial construction was a timber crib and piling structure. The embankment was earthfill with timber diaphragm core, protected by sod and riprap surfacing. Beginning in 1899, the timber crib superstructure was removed and a new concrete superstructure was constructed in its place, with reconstruction completed in 1901. A steel bridge was constructed across the structure in 1909, with subsequent replacement in 1934. The tainter gates, bear trap gate, and operating machinery were removed in 1931, and operation from that time until 1966 was by stop logs only. In 1966, five of the stop log bays were fitted with steel slide gates. Considerable repairs were needed from time to time on the timber aprons, and in 1964-1966 a concrete apron was installed. The embankment and perimeter dikes were raised, strengthened and riprap repaired on several occasions during the early history of the project. The upper operating limit of the reservoir has been exceeded twice (in 1905 and 1950), but the flowage limit has never been exceeded.

7. With the additional development of the 9-foot channel locks and dams in the 1930's, and the more recent completion of the lock at Chain of Rocks near St. Louis, Mo., the necessity for supplemental flows has been considerably reduced and a greater emphasis has been placed on flood control, recreation, conservation, and related uses.

PROJECT DESCRIPTION

8. Winnibigoshish Dam is located on the Mississippi River in north central Minnesota, 1247.9 river miles above the mouth of the Ohio River. The Dam is at the outlet of Winnibigoshish Lake, at the southeast end of the Lake, about 14 miles northwest of Deer River, Minnesota, in Leech Reservation in the southwest portion of Itasca County. It is approximately 170 river miles downstream from the source of the Mississippi in Lake Itasca, and 408 river miles above St. Paul, Minnesota. The project location is shown on Plate 1 and existing project features are shown on Plates 2, 3, 4 and 5.

9. Winnibigoshish Dam is a dual purpose project designed primarily to augment low flow at St. Paul for navigation and secondarily to provide flood protection to the agricultural area of Aitkin. The lake is also used for recreation and the recreational users have requested that it be kept at steady level.

10. The four principal features of the dam are: (1) an embankment of riprap, concrete and grout protecting a timber diaphragm with puddled clay core; (2) a non air entrained reinforced concrete control structure; (3) a concrete spillway apron; and (4) a series of four dikes providing flood protection to sites near the Lake eight miles from the main dam.

11. Winnibigoshish Dam consists of an earth dike 800 feet long with a timber diaphragm, filled with puddled clay for a core wall. It is capped with sod, and the lake side from the control structure to the right bank is protected by a concrete slab. A large part of the main embankment is protected with grouted riprap. The top of the dike carries a 20 foot roadway.

12. The control structure consists of reinforced concrete abutments and piers, supported on timber piling. There are five 14-foot sluiceways, each of which is divided into three sections of stoplogs, and each sluiceway has a 3 1/2 by 5-foot slide gate. In addition, there are a 12-foot log sluice and a 5-foot fishway (no longer used) in the structure. The total length between abutments is 162 feet. The control structure also supports a 20-foot highway bridge which has a treated timber deck and sidewalk laid on steel stringers, which are supported between the abutments by six steel bents and one concrete wall.

13. Four dikes were constructed along the southern perimeter of the Lake near the village of Bena. Dike No. 1 is short and low, with a maximum height of 2 or 3 feet, and is probably buried under State Highway No. 2. Dike Nos. 2, 3, and 4 prevent escape of water to the south from Winnibigoshish Lake to Leech Lake via Six Mile Lake. These three dikes are essential during a flood to prevent overflows to Leech Lake. Pertinent data on Winnibigoshish Dam, Winnibigoshish Lake and the perimeter dikes are presented on Tables 1, 2, and 3, respectively.

14. The headwaters area is generally covered by a mantle of glacial drift ranging in depth from 100 to 300 feet which is composed of a hetergeneous mixture of sand, gravel and boulders. Although outcrops of rock are found in isolated areas throughout the area, the most notable are in the vicinity of Pokegama Dam.

15. The parent material of the Winnibigoshish Dam and Lake area is a combination of glacial till plain and moraine and is characterized by many small lakes and flat to hilly topography. The soils are typically a clayey, silty, sand with some gravel and stone. There are three types of glacial drift, whose deposition during the Wisconsin age over 10,000 years ago are responsible for the gently rolling topography. The area from northern Gull Lake to Leech Lake in the southwestern portion of Cass County is part of the St. Croix moraine system. In the north along the southern edge of Lake Winnibigoshish there is a sandy outwash plain. South of this outwash toward and in the area of Leech Lake is a major area of till plain.

Table 1. Pertinent Data - Winnibigoshish Dam

Location: Lat 47°25'42", long 94°03'00", in sec.25, T.146 N., R.27 W., Itasca County, at dam on Mississippi River, 1 mi (1.6 km) northwest of Little Winnibigoshish Lake, 14 mi (23 km) northwest of town of Deer River, and at mile 1,248 (2,008 km) upstream from Ohio River.

Type of Project: Navigation and Flood Control
Mississippi River Headwater Reservoir

Objectives of Regulation: Primary - Augmentation of low flows on the Mississippi River, between St. Paul and Lake Pepin for navigation

Secondary - Flood Control, Recreation, Power, Water Supply, Fish & Wildlife

Regulation Agency: U.S. Army Corps of Engineers, St. Paul District

Real Estate Take Line for Easement: Up to elevation 1306.9 (M.S.L. 1929 Adj.), total area 147,164 acres

Maximum Pool Elevation of Record and Date: 1303.4 (M.S.L. 1929 Adj.) July 30, 1905

Minimum Average Daily Flow and Date of Occurrence: No flow at times. The St. Paul District follows the policies set forth by the State of Minnesota (under Statutes 1961, section 110.51) and the Corps of Engineers in regard to regulation of the Headwater Reservoirs.

Average Annual Flow: 516 CFS (92 years of record)

Maximum Average Daily Flow and Date: 4370 CFS, August 6, 1905

Name and Location of Key Stream-flow Stations: Tailwater, Winnibigoshish Dam

Type of Hydrometeorlogic Data Recorded at Damsite: Precipitation, Temperature, Cloud Cover, Wind

Number of Sediment Ranges: None

Drainage Area above Dam: 1442 square miles

Table 1. Pertinent Data - Winnibigoshish Dam (Cont'd)

Dam	
Type	Earth fill with timber diaphragm core
Elevation top of dam (m.s.l., 1929 adj.)	1311.4
Length of crest (total, feet)	1000
Control Structure	
Type	Reinforced concrete
Net length spillway crest (feet)	82
Elevation of piers (feet)	1304.4
Length between abutments (feet)	165.4
Sill elevation (m.s.l., 1929 adj.)	1285.2
Number of sluices - with gates and stoplogs	5 (each divided into 3 sections of stoplogs)
Size - sluices (feet)	14 (each)
Size - gates (feet)	3.5 x 5 (each)
Number of sluices - with stoplogs only	1 (12' wide)
Gate invert elevation (m.s.l., 1929 adj.)	1285.2
Spillway Apron	
Type	Concrete
Length (feet)	148.5
Width (feet)	138.5
Bridge	
Type	Steel with treated timber deck
Length (feet)	168.6
Number of spans	7
Roadway width (feet)	20
Walkway Elevation (feet)	1312.4
Roadway Elevation (feet)	1311.4

60. Without performing a detailed cost estimate of the work involved in this plan it can be realized that it would be extremely costly in comparison to other possible alternatives. Because there is no real advantage in raising the dam embankment, roadway and perimeter dikes over other possible alternatives, this plan was eliminated.

PLAN 3 - CONSTRUCT A NEW ADDITIONAL SPILLWAY

61. An additional uncontrolled 250-foot-wide concrete overflow section with a grass-lined spillway chute would be established to discharge an additional 11900 cfs above the existing spillway capacity of 5900 cfs at a peak elevation of 1306.00. The crest would be set at a minimum elevation of 1299 ft.

62. There are uncertainties as to where exactly the spillway could be constructed because there is a fish hatchery to the right of the control structure, downstream of the embankment and the damtenders residence and a recreation area are located to the left of the control structure. Therefore this alternative has been eliminated.

PLAN 4 - WIDEN EXISTING SPILLWAY

63. The existing spillway would need to be widened by 24 ft. with vertical lift gate type controls; invert elevation at 1285.2 and maximum opening to elevation 1302.0, to pass a peak discharge of 10,600 cfs at elevation 1306.3, while providing 5.1 ft. of freeboard.

64. Because this water surface elevation can be maintained more economically as described below in plan 5, this plan has also been eliminated.

65. Widening the spillway and providing the same spillway crest elevation and control works as existing conditions is also not recommended because the length of additional spillway required would be extremely long.

PLAN 5 - MODIFY SPILLWAY CONTROLS

66. If the embankment were to remain the same height, additional spillway capacity would be required to maintain 5-feet of freeboard. This could be accomplished by modifying the existing spillway.

67. The existing outlet controls at Winnibigoshish Dam consist of 5 - 14 ft. wide sluiceways, each divided into three sections of stoplogs and each sluiceway having a 5 x 3 1/2 ft slide gate, and 1 - 12 ft. wide stoplog bay. The scenario chosen for routing the PMF through the existing structure was one in which only the slide gates were open. This was assumed because of the time and manpower constraints associated with removing the stop logs.

68. Modification to the existing spillway controls would allow additional capacity. Three levels of one basic plan have been evaluated as discussed below as plans 5A through 5C.

1. Remove entire dam.
2. Raise and improve the existing dam embankment and dikes.
3. Construct a new additional spillway.
4. Widen existing spillway.
5. Modify spillway controls.
6. Perform extensive maintenance only.
7. Accept existing condition, acquire inundated land downstream

PLAN 1 - REMOVE ENTIRE DAM

56. Removal of the entire dam would involve removing the embankment, spillway, and outlet structures.

57. As stated earlier, it was determined that during the PMF, the effects of flooding on the land between the dam and Grand Rapids, with the dam not in place would be worse than those occurring if the dam were there. Results indicate that the dam significantly reduces the PMF discharge downstream. Also, the recreational opportunities that the reservoir provides, play a significant role in the stabilization of the area's economy. This role has been increasing substantially over the past few years, and removal of the dam and reservoir would severely harm the area's economy and growth. For these two reasons, this alternative has been eliminated.

PLAN 2 - RAISE AND IMPROVE THE EXISTING DAM EMBANKMENT AND DIKES

58. A 1.5-foot raise of Winnibigoshish Dam to elevation 1312.9 would be needed to meet the 5-foot freeboard requirement. The existing spillway crest elevation (effective elevation) of 1301.3 and length (82 feet) would be maintained to discharge the PMF peak outflow of 5900 cfs at a pool elevation of 1307.9 while allowing 5 feet of freeboard. The 1000 ft. length of main embankment and roadway, and both the inlet walls and chute walls would have to be raised approximately 1.5 feet. The same stilling basin width (82 ft.), floor elevation (1282.64) and length (113 ft.) would be maintained. However, the height of the basin walls would have to be increased by approximately 1.5 feet. A sloped end sill would be provided at the downstream end of the basin. Perimeter dikes 2, 3 and 4 would need to be resurveyed and raised to elevation 1312.1 with slope protection provided. This elevation provides 4.2 ft. of freeboard above the PMF elevation and meets design wave criteria.

59. At the present time little is known about the foundation. It can be assumed that when the embankment was built, the rate of fill placement was comparatively slow. Sufficient information about deeper strata in the foundation should be obtained to assure that excessive pore pressure and deformations do not develop. A solution to modify the embankment to meet stability requirements or upgrade the dam by raising or widening the top could significantly change the foundation loading, necessitating a detailed analysis. However, before this could be accomplished a well developed plan for implementing a foundation-embankment exploration and a laboratory testing program must be initiated.

52. Damages in the headwaters reservoir area due to low water, particularly during the recreation season can be of material significance since low water exposes unattractive shore areas, makes dock and shore line installation ineffective, results in obstructing normally navigable connecting channels, and produces a reduction in resort patronage which may be felt for several years. In addition, low stages endanger fish life and in certain shallow connecting lakes may be responsible for substantial fish kills. In this connection, the Minnesota DNR has made preliminary studies of water levels maintained during recent years and has concluded that the present reservoir operating schedules are generally satisfactory from a fish and wildlife point of view.

CONSEQUENCES OF NOT ACCOMPLISHING NEEDED REPAIRS OR MODIFICATIONS FOR DAM SAFETY

53. Presently, required modifications to the dam embankment, control structure and perimeter dikes include those for a cost-effective plan to safely handle the Probable Maximum Flood (PMF) while maintaining 5-feet of freeboard, and insuring structural stability. The hydrologic analysis as prepared for the Dam Failure Planning Report indicated that the maximum water surface elevation that would be attained at the dam in the event of the PMF is 1307.9, providing only 3.5 feet of freeboard. Thus modification is needed in order to meet this hydraulic safety requirement. Below several alternatives to accomplish this are evaluated. Modifications to insure structural stability are required whatever plan is recommended. The four areas of concern, as described previously in this report are: (1) embankment stability under all conditions; (2) safety of the piles that support the piers in their resistance to shear loads; (3) deterioration of the concrete surfaces; and (4) the need to clean and paint the steel surfaces. These will be addressed in relation to the recommended plan only.

54. Without modifications, potential failure of Winnibigoshish Dam during the PMF would result due to erosion of the downstream face of the embankment. Erosion could progress until breaching of the dam occurred, with the resulting flood wave causing limited property damage to downstream structures such as bridges, in addition to several dwellings along the floodway. There also exists the potential for damage to property in the city of Grand Rapids, Minnesota although it is unlikely that there would be a threat of loss of life.

ALTERNATIVES CONSIDERED

55. In an effort to eliminate the safety deficiency, of not meeting the 5-foot freeboard requirement at Winnibigoshish Dam, the following alternative plans were formulated and evaluated:

WATER SUPPLY

48. Water is obtained from the Mississippi River for municipal water supply by the cities of Minneapolis, St. Paul, their suburbs, and the city of St. Cloud. All Minnesota municipalities located along the Mississippi River that have municipal sewage disposal systems discharge sewage treatment plant effluent or untreated sewage into the river. Studies made by the Minneapolis-St. Paul Sanitary District show that with probable population increases in the urban area served by the district, it will not be possible at all times to maintain the river in satisfactory condition without augmenting low river flows, even if there is the best possible treatment of the sewage.

49. Because of the growing need for water by the various interests in the state, the Minnesota Commissioner of Conservation has adopted a plan of operation for the headwaters reservoirs. This plan coincides with the Corps of Engineer's plan of operation but provides detailed regulation when the reservoirs are not functioning for the primary purposes of navigation and flood control.

RECREATION

50. Throughout the years there has been a gradual occupation of the land around the reservoirs, including the flowage, by summer resorts, private cottages, and all-year homes with accompanying improvements. Developments around the headwaters reservoirs during the past few years has been increasing substantially each year with no indication of any letup in this trend. While there are many resorts the trend to private installations appears to be increasing with larger and more costly structures appearing. Development of public access, camp grounds and recreation facilities are being established by the U.S. Forest Service and the State of Minnesota. This situation has made it difficult for the Corps of Engineers to fully use the storage range as originally planned. Experience has shown that although the Corps of Engineers may have the legal right to raise the levels of the reservoirs to maximum operating stage which causes damage in the reservoir area, it is not practical to do so. Concessions have been made from time to time by revisions of the operating plans.

51. This recreational aspect of Winnibigoshish Lake has become a vital economic factor to the general area. During the earlier years of the dam operation the normal recreation period was from May through October, providing area businessmen only a limited six month period of income. More recently, however, as winter sports became popular (i.e. skiing and snowmobiling) the area has become more economically stable.

PROJECT USE

GENERAL

45. The Mississippi River headwaters reservoirs were constructed primarily for the storage of water to improve navigation on the reach of the Mississippi River from St. Paul, Minn., to Lake Pepin. Construction of the reservoirs was authorized by Congress and Congress directed the Secretary of War to establish regulations governing their operation. However, with the canalization of the Mississippi River below Minneapolis, Minn., the demands for storage releases from the reservoir system for navigation have been greatly reduced. For many years, the agricultural area of Aitkin has made demands on the Corps of Engineers to use the reservoirs for flood control in order to alleviate the disastrous effects in that area. On the other hand, many private property owners and resort interests with property adjoining the reservoirs have requested that the reservoirs be kept at steady levels during the resort season. Through public hearings, the Corps of Engineers has established operating limits generally acceptable to the majority of these people. After Labor Day the reservoirs are operated to draw down their levels by spring breakup in order to provide storage for the expected spring runoff. The general plan of the operation of the headwaters reservoirs assumes the maximum beneficial use of these reservoirs for all concerned under the present conditions, giving preference to the requirements for navigation and flood control.

46. At Winnibigoshish Dam, during periods of abnormally high inflow, storage is used up to elevation 1303.1 feet. Flowage rights have been acquired to an elevation of 1306.9 feet to allow for wave action and seepage damage. Stored water is released if required during the summer to augment stream flows for water supply, water power, or other beneficial uses. To provide storage capacity for the spring runoff, the reservoir is lowered during the winter months to reach an elevation of 1296.9 feet by 1 April. Outflow during the spring breakup period usually does not exceed 100 cfs.

FLOOD CONTROL

47. Floods of damaging proportions occur in the Mississippi River Valley above Brainerd, Minnesota as a result of rapid snow-melt, augmented at times by spring rains, and following prolonged periods of above-normal summer rainfall. The focal point of repeated damaging floods in the headwaters area is Aitkin and vicinity although large areas of poorly drained marsh and timberlands throughout the basin have been frequently flooded. Because of the large amount of storage provided by the many lakes and swamps in the basin and the operation of the headwaters reservoirs, floods are not of a flashy nature and considering the size of the drainage area, are not of unusual magnitude. Floods in the Aitkin area are characteristically of long duration, rising gradually to crest and receding slowly.

ICE LOADING

43. Ice loading was planned for in the original design of Winnibigoshish Dam according to early annual reports of the Chief of Engineers to Congress. It was theorized that ice loading caused the rapid deterioration of the original timber control structure. At the time it was rebuilt, using the riprap protection of the upstream slope for aggregate for the concrete piers. Ice loading has not been a problem at the site in later years. However, ice loading could be contributing to crack propagation of the present grouted concrete embankment protection.

HISTORY OF MAINTENANCE AND REHABILITATION OR MODIFICATION FOR DAM SAFETY

44. A list of principal contract expenditures to date, excluding contracts for recreational facilities, are shown on table 4. Costs are based on contractors bid cost only, and do not include modifications, change orders, or Government costs.

Table 4 - Summary of Major Construction and Maintenance Contracts

Description	Completed	Contractor	Amount
Dam Construction			
Original	1881-1884	Hired Labor	$ 238,000.00
Reconstruction	1891-1901	Hired Labor	144,261.00
Control Structure Reconstruction	1902	Hired Labor	$128,857.15 (to 1 July 1900)
Embankment Slope Protection Repair By Sand Cement Mix	1907	(Unknown)	$ 400.00
Taintor Gates and Operating Machinery Removed	1931	(Unknown)	(Unknown)
New Bridge Built & Apron of Dam Sealed	1934	M.E. Souther, Inc.	$ 9,675.00
Embankment Pavement Repaired	1944	(Unknown)	(Unknown)
Left Bank Riprapped	1948	Harland Noble	$ 690.00
Discharge Channel Riprapped	1949	Harland Noble	$ 3,750.00
Spillway Apron Rehabilitation	1965	(Unknown)	$ 71,943.00

vice for 80 years or more without air entrainment, deterioration can be expected. It remains to be decided whether the piers should be rebuilt or coated with a protective material. The 1981 stability analysis recommended that the piers be patched because the interior concrete is in good condition. However, if the spillway is modified and the dam is raised it may be worthwhile to rebuild the upper piers if a good joint can be installed to the old concrete below the freeze thaw zone of the soil.

SEDIMENTATION

39. Results of the periodic inspection reveal a siltation problem developing. It was recommended that an upstream sounding program be developed using pre-established, repeatable ranges. It was suggested that these soundings be taken at least prior to each periodic inspection or following sustained periods of high flow. Annual soundings were suggested until a data base was formed and as warranted by field conditions, thereafter.

40. A cursory examination of a report by Frank J. Mack of Rock Island District on "Sediment Yields in the Upper Mississippi River Basin" contained in Proceedings of a Seminar on Sediment Transport in Rivers and Reservations, 7-9 April 1970 shows that for area 90, the area of the headwaters, for a 1,000 square mile resource area the annual sedimentation yield in tons per square mile is 7. Using $Y = K/A^n$, $K = 15$, $n = .12$ and $A = 1442$ sq miles, the yield for Winnibigoshish would be 6.3 tons per square mile per year.

41. Assuming that the yield remains constant rather than varying with storm size and intensity, and assuming a 203,400 acre foot volume for the reservoir and sediment with a unit weight of 70 pounds per cubic foot, and a reservoir containment area of 45.4 square miles, it could take over a million years for the reservoir to fill up with sediment. However, the load on the structure will become appreciable before that time. For this reason soundings are recommended. Also, soundings have been recommended in the past for this dam to determine the effects of erosion on the embankment which is covered by grout and in which hollow sounding areas have been noted.

EARTHQUAKE LIQUEFACTION

42. Winnibigoshish Dam is located in earthquake zone 1. Because the foundation of the Winnibigoshish control structure piles rests on saturated sand and the blue clay on which the embankment appears to rest appears to be on the same sand, it is suggested that sufficient characteristics of the foundation and pore pressure regime be obtained to allow a liquefaction analysis to be performed. Such a liquefaction analysis could assist in determining the susceptibility of Winnibigoshish Dam to an earthquake in view of renewed national interest in earthquakes in the interior of the United States. As part of this recommended analysis, a review of the on site testing performed by the Waterways Experiment Station as part of their September 1981 structural stability evaluation of Winnibigoshish Dam should be undertaken as the first step of the liquefaction analysis.

SPECIAL CONDITIONS SINCE COMPLETION

SEEPAGE

34. Three 6-inch VCP drain outlets were found in the field during the 1973 periodic inspection, one outletting through the fishway abutment wall and the other two outlets on the downstream slopes at the back sides of both the right and left control structure abutments. The drains were not checked to see if they were open, but some drainage was observed flowing from each of the drains.

35. Seepage was evident at abutment cracks and joints. The discharge level of the seepage indicated that the condition was normal, and the amount of seepage flow was not significant. Seepage on the piers was noticeable also, particularly at the edges of the steel armor plate for the old Parker Bear Trap and old tainter gates. Both horizontal and vertical lift joints on the piers show efflorescense and other signs of seepage, especially just above the tailwater level. No detrimental seepage at joints and cracks was observed.

36. The outlet channel riprap at the downstream left abutment wall was wet and soggy to about 20 feet away from the wall, at the level of the 6-inch VCP drain outlet. The seepage appeared to be trapped behind the wall and below the level of the drain outlet, thereby being forced to exit in the riprap. The source of this seepage was not ascertained. It was determined that the source could have been either from rainfall or from the pool via the back side of the abutment and/or through the timber diaphragm in the embankment. The seepage could be caused to exit in the riprap because the drain line is located too high to pick up the seepage, or the drain could be broken or partially plugged so that most of the discharge is from the drain into the riprapped area. It was recommended that this seepage be observed for any change, and an evaluation of the cause or causes would be required if seepage quantities became excessive. Observation wells could have been set to check the effectiveness of the timber diaphragm cutoff, but were not considered necessary at that time.

37. It has been noted earlier in this report that springs were found in the control structure floor when it was rebuilt in 1900. The springs were observed to apparently emanate from a source higher than the original lake at that time.

CONCRETE DETERIORATION

38. An extensive crack survey was part of PIR No. 2. One possible reason for the concrete deterioration in the upper layers of the piers is due to higher water contents in the upper portions of a lift, with the result that disintegration caused by freezing and thawing is usually more serious at the top of a lift than elsewhere. The lift thickness was reported to be six inches in the year 1900. It may have been very difficult at that time to lower the water content as the top of a lift was approached and still maintain adequate workability. The added durability of concrete to cycles of freezing and thawing by the addition of about 3% air entrainment is now well known. Considering that the concrete of these piers has been in ser-

cross section these funds should be allocated. Because it is not known at present what provisions were made for seepage when the embankment was constructed, because the type of material of the embankment is only briefly described, and because significant advances have been made since 1885 when the dam embankment was first completed and the first control structure operated, the work schedule should be accomplished as soon as possible. Preliminary results of the evaluation indicate that stability requirements for the conditions of partial pool and steady seepage could be achieved by flattening the upstream slope or placing a berm along the upstream toe. More recent evaluation indicates that the top width of the existing embankment should be widened 8 feet and the upstream and downstream slopes flattened to 1V to 3.5H. The embankment widening will require new upstream concrete wingwalls. The existing bituminous roadway should be removed and the underlying embankment thoroughly compacted with a large vibratory roller. A new sub-base, base course and bituminous roadway should be constructed. Additionally, a 24-inch culvert with manholes should be installed in the existing downstream ditch parallel to the dam and the ditch backfilled to natural ground. The associated cost for these recommendations is estimated to be $392,400. A detailed cost breakdown is shown on plate 17.

Control Structure

31. The interior concrete of the control structure was reported (reference six) to be of good quality, but the concrete and steel surfaces are deteriorating. The report recommended that the concrete surface be rehabilitated to insure that water is not allowed to enter cracks and accelerate the deterioration of the concrete. The soil-piling system that supports the piers at the dam is adequate except for the safety of the piles in their resistance to shear loads. The report recommended that 135 kips of strut resistance be assured downstream of each interior small pier. This could be achieved by providing "soil anchors" at each pier. The wood decking, supporting beams, and piling have been continuously submerged and from samples of the material from core hole W-P1, it was determined that the wood is in excellent condition. The report also recommended that the steel surfaces be cleaned and painted.

32. The conclusions developed in paragraphs 31 were proposed by the Waterways Experiment Station in their analysis of the control structure. It appears that a liquefaction analysis is also necessary as indicated in more detail by paragraph 42.

SPILLWAY CAPACITY

33. The major concern with the existing spillway is its inadequate capacity. This inadequacy is a result of the physical limitations in operating the control gates. At present there are 16 stoplog sections that are operated manually, and five slide gates. It was assumed that to remove the stoplogs and open the slide gates in a reasonable time period was impossible. Therefore, the operating arrangement adopted for routing the Probable Maximum Flood through the dam was one in which all the stoplogs were in place, and only the five slide gates fully open. The spillway capacity at design flood stage is 1000 cfs. The current hydrologic analysis for Winnibigoshish Lake indicates a peak inflow for the Probable Maximum Flood of 67,500 cfs. Routing this inflow through the reservoir results in a peak outflow of 5,900 cfs, and a maximum elevation of 1307.9, allowing for 3.5 feet of freeboard. The current freeboard requirement is 5 feet. Thus, additional spillway capacity is necessary to permit discharge of large floods while meeting the freeboard requirement.

Perimeter Dikes

26. The perimeter dikes were inspected in October 1973. Those sections that were readily identifiable probably would withstand a flood, but have been badly neglected. There has been no maintenance in the past 10-20 years. Dikes 3 and 4 have been utilized in the past, at least in 1905 and 1950. These dikes evidently functioned on their own and apparently were adequate for those floods. The dikes are needed, and should be maintained as recommended in the following paragraph.

27. Since dikes 3 and 4 would be needed during major floods to prevent escape of water from Winnibigoshish Lake to the Leech Lake River via Six Mile Lake, the integrity of these dikes must be assured. The dikes should be maintained in good condition and an all weather access is needed. As a minimum, all trees on dikes 3 and 4, and within 10 feet of the toes of these dikes, should be cut down. It would be desirable to obtain more information on location, grade, and section of all the dikes, but the information to be gained probably does not justify the cost of the survey. The ends of the dikes should be marked and identified by markers such as those used for the Pine River Perimeter Dikes. Extensive survey information appears to be briefly summarized in the Annual Reports of the Chief of Engineers to Congress if a new survey is not desired. Of course if the monuments are lost or defaced a new survey will be necessary.

Bridge

28. The structural elements of the bridge are in satisfactory condition. As previously reported in PIR No. 2, the asphalt bridge deck driving surface is cracked in places. The roadway approach dips have not been repaired since the last inspection. The downstream wooden curbs are continuing to deteriorate. A void was found under the right downstream roadway approach slab. The bridge bearing seats have been repaired (grouted) and documented. The void should be repaired to prevent failure of the slab.

STABILITY ANALYSIS

29. A structural stability analysis of Winnibigoshish Dam, limited to an evaluation of the concrete control structure with consideration given to foundation and concrete properties, was completed in 1981 by the U.S. Army Corps of Engineers, Waterways Experiment Station. The findings of this analysis are discussed in reference six. An evaluation of embankment and foundation stability was undertaken in 1983. No previous embankment stability analysis had been performed on this dam. The locations of soil boring logs made in 1958 and 1980 are shown on Plate 8. Typical boring logs are shown on Plates 9 and 10.

Embankment

30. An embankment stability analysis and report are presently in preliminary form. Structural drilling and testing are to be conducted in the latter portion of FY 85; and a structural analysis and report and the dam structural stability analysis were to be scheduled in FY 86, provided funds were available. Due to the age of the dam and uncertainty of its as-built

PERIODIC INSPECTION RESULTS

22. An inspection and evaluation of the bridge was made on 1 December 1971. The first periodic inspection of Winnibigoshish Dam was held on 3 October 1973. In October 1975 a supplemental inspection of the dam and bridge was made. One subsequent periodic inspection was conducted on 14 August 1979. Another inspection was made on 17 August 1981.

Embankment

23. Evaluation of the embankment reveals that rutting in the bituminous embankment roadway as reported in Periodic Inspection Report (PIR) No. 1 is still evident. A longitudinal crack in the pavement runs a considerable length of the dam. Highway maintenance crews apply crack sealer on an annual basis to minimize the effect of impounded surface water entering the embankment fill and the damage that could result. PIR No. 1 also noted that in these same areas the grouted riprap at the water line was badly cracked and undergoing displacement, with some rock missing just below the water line. However, it was stated in PIR No. 2 that the upstream embankment riprap is in satisfactory condition and that the grouted surface did not appear to be deteriorating and no new cracking was observed. The entire upstream face was sounded with a rebar and, although there were many areas that sounded hollow from 0 to 5 feet above the pool and in the top 3 to 5 feet of slope, the center third of the riprap was sound. Vegetation is growing through the cracked grout. The downstream slope and toe area were reported to be satisfactory and the surface firm and dry with no sign of seepage or instability. A flow of about 10 gpm was observed in the ditch outlet just upstream of the fish and wildlife impoundment dike parallel to and about 100 feet downstream of the embankment toe. It is believed that this flow is seepage from the fish and wildlife impoundment and not through or under the project embankment.

Control Structure

24. As reported in PIR No. 1 the concrete in general is in good condition. (Only the concrete above the water surface could be observed because the control structure had not been dewatered). Some signs of deterioration were evident but in terms of stability and safety the concrete was believed to be sound. PIR No. 2 report observed change/additions of the concrete that were old in appearance and probably were those reported during the 1971 inspection. On the upstream side of the log sluice and fishway stoplogs, sand and/or silt has accumulated but no sounding data has been taken upstream of the structure. There are also some rust spots on the gate machinery walkway floor plates.

Spillway Apron

25. The spillway apron, originally of timber flooring, was rehabilitated in 1964 with completion in August 1965. The outlet channel floor has been observed during times of low water to be without deposition and scour. The apron has not been observed by the method of dewatering during the two periodic inspections. However, the downstream apron concrete has been observed by the dam operator and was reported to be in good condition prior to the 1973 Periodic Inspection.

16. Preliminary borings, made in the headwaters area of the Mississippi with gas pipe before 1878, showed the sites to be underlain by blue clay of the best quality. These borings also showed that the blue clay existed in the banks and that it was readily accessible for construction. In a report dated 14 December 1880 from the Chief of Engineers to Congress, it was stated that "the dam site was a bed of clay overlaid to a depth of 3 to 5 feet by mud, and underlaid by sand at a depth of 10 to 15 feet." Borings, made by the Waterways Experiment Station in 1981, through the piers, confirmed that the timber piles upon which the control structure is founded, rest upon a foundation of saturated sand and gravel.

17. The earth embankment consists of a puddled clay core with a timber diaphragm. The puddled clay is most likely the blue clay mentioned in the preliminary borings. The piles were apparently driven into the clay layer of the foundation and no cutoff trench appears to have been provided at the time of original construction since the piles were apparently to intercept only the top of the clay layer. In reconstruction of the control structure in 1900, round sheet piles were driven and the floor above then relaid. The space between the cofferdams was allowed to fill with water supplied by springs within this area. These springs have their source higher than the surface of the lake, as was shown by the water within the cofferdams rising 14 inches higher than the level of the lake. A sluice was put in through the lower cofferdam to prevent further rise.

18. The embankment was originally covered with 9 to 12 inches of rock to protect it from waves. In 1897, when there was a head of over 11 feet on the lake, it was discovered that it was not a proper protection against a sea. The rock was therefore removed from the embankment for concrete purposes with the intention of protecting it later on in some way not yet decided on. During reconstruction of the control structure in 1900 the amount of rock removed from the embankment was about 2,100 cubic yards. The amount removed from the old crib work was about 1,900 cubic yards with about 500 cubic yards removed in 1901. The amount of rock crushed for concrete aggregate for the control structure was about 1,900 cubic yards.

19. In 1902 upstream embankment slope protection was completed. In 1906 the slope protection was repaired using a sand cement mix, after record 1905 flood stages. In 1949 the discharge channel banks were riprapped.

20. The reinforced concrete control structure also serves as the spillway. The superstructure piers and abutments were rebuilt in 1900 and 1901 after considerable deterioration made the original timber control superstructure unsafe rendering the dam inoperable from 1898 to 1902. The mix design for the concrete pier monoliths of the control structure was approximately a 1:3:6.

CURRENT CONDITION

21. Photographs showing the current condition of the control structure are presented on Plates 6 and 7.

Table 3 Pertinent Data - Winnibigoshish Lake, Perimeter Dikes

Number	1[1]/	2	3	4
Length (feet)	170	400	770	420
Height (feet)	2-3	-	5-8	5
Top Width (feet)	Unknown	32	17	10
Surface	Unknown	Trees	Trees	Trees
Slope (Lake)	Unknown	1V:2H	1V:2H	1V:2H
Slope (Land)	Unknown	1V:3H	1V:1.5H	1V:3H

1/ Perimeter Dike Number 1 is the Highway 2 embankment.

Table 2 Pertinent Data - Winnibigoshish Lake

Inactive Storage Pool	
Elevation (m.s.l., 1929 adj.)	1294.9
Area (acres)	57,000
Storage (acre-feet)	314,000
Regulated Outflow - minimum (cfs)	50
Recreation Pool	
Elevation (m.s.l., 1929 adj.)	1298.4
Area (acres)	76,000
Storage (acre-feet)	268,000
Regulated Outflow - minimum (cfs)	100
Regulated Outflow - maximum (cfs) (Channel Capacity)	2000
Flood Control Pool	
Elevation (m.s.l., 1929 adj.)	1303.1
Area (acres)	115,000
Storage (acre-feet)	385,000
Regulated Outflow - minimum (cfs)	100
Regulated Outflow - maximum (cfs) (Channel Capacity)	2000
Real estate take line for easement Up to Elevation 1306.9 (M.S.L. 1929 adj.) - total area (acres)	147,164
Spillway Design Flood (SPF)	
Peak Inflow (cfs)	23,400
Peak Outflow (cfs)	1000
Maximum Elevation (ft above m.s.l., 1929 adj.)	1304.4
Storm (inches)	7.06
Runoff-includes baseflow (inches)	4.66
Probable Maximum Flood	
Peak Inflow (cfs)	67,500
Peak Outflow (cfs)	5,900
Maximum Elevation (ft above m.s.l., 1929 adj.)	1307.9
Storm - includes snowmelt (inches)	20.99
Runoff (inches)	12.23

Plan 5A - The minimum level of modification necessary in order to meet the hydraulic safety requirement is to provide 14 ft-wide vertical lift gates at bay areas 1 and 5, with no modifications to the remaining four bay areas. Sill elevations at these two bay areas would remain at 1285.2 and opening of the lift gates would be allowed to elevation 1302.0. The maximum operating capacity required to safely handle the PMF while maintaining 5 feet of freeboard with this plan could be achieved with the lift gates and slide gates fully open. None of the stop logs would have to be removed. During the PMF the spillway would have the capacity to pass a peak discharge of 10,500 cfs at a maximum reservoir water surface elevation of 1306.3 providing 5.1 feet of freeboard.

The cost of this alternative for spillway control and pier stabilization is estimated at $729,400.00. Project features of Plan 5A are shown on Plate 11.

Plan 5B - This plan is identical to Plan 5A except that the three remaining 3 1/2 x 5 ft manually operated slide gates would be equipped with mechanically operated controls. This would allow ease in operations of all controls, thereby modernizing the control structure somewhat. However the remaining stoplogs will be left in place and need not be removed for operating purposes. The hydraulic characteristics will remain exactly as in Plan 5A. The cost of mechanizing the 3 slide gates is estimated at $23,400.00 bringing the total cost of this alternative to $752,800.00. Project features of Plan 5B are shown on Plate 12.

Plan 5C - This plan is to totally modernize the control structure by providing 14 ft-wide vertical lift gates at bay areas 1 through 5 and pier stabilization. The 12 ft-wide stoplog sluiceway (bay area 6) would be completely closed off. Sill elevations of all gates will remain at 1285.2, and opening of the gates will be allowed to elevation 1296.00. The spillway would have the capacity to pass a peak discharge of 12,400 cfs while maintaining a maximum reservoir water surface elevation of 1305.1 allowing 6.3 ft of freeboard. The cost of this alternative is estimated at $1,557,200.00. Project features of Plan 5C are shown on Plate 13.

The tailwater elevation for these different plans can be obtained from the Dam Failure Planning Report, Winnibigoshish Dam. The stilling basin may need some modification. The detailed hydraulic design for any changes required will be done during detailed design phase.

Some of these plans raise the PMF water surface elevation above the top of pier. Any flow over the pier top is not considered because during floods, debris and logs usually accumulate at the upstream face of the piers thus restricting or eliminating any flow over the top of the piers.

The structural stability of the piers due to additional head should be addressed in the detailed design phase of the study.

PLAN 6 - PERFORM EXTENSIVE MAINTENANCE ONLY

69. This alternative would involve action to be taken to protect the embankment from erosion, ascertain the erosive nature of the embankment material, establish sediment sounding ranges, provide for improvement and maintenance of the perimeter dikes and patching of the control structure concrete. In addition, a liquefaction analysis and an embankment stability analysis are recommended. Also it is suggested that a survey of all government documents pertaining to the as-built embankment and control structure be made. However, with this maintenance done, the dam will still not meet the safety requirement of passing the PMF while providing 5-feet of freeboard. Therefore this plan is unacceptable, and has been eliminated.

PLAN 7 - ACCEPT EXISTING CONDITION, ACQUIRE INUNDATED LAND DOWNSTREAM

70. Accepting the existing condition of Winnibigoshish Dam and purchasing those lands (some of which are held in trust by the Bureau of Indian Affairs) downstream that would be adversely affected was also evaluated. It was determined that during the PMF, the effects of flooding on the land between Winnibigoshish Dam and the city Grand Rapids with the dam in place (with project condition) would not be worse than those occurring if Winnibigoshish Dam were not there (without project condition). Therefore, this alternative was eliminated.

RECOMMENDED PLAN

71. The existing outlet controls at Winnibigoshish Dam consist of 5 - 14 ft wide sluiceways, each divided into three sections of stoplogs and each sluiceway having a 5 x 3 1/2 ft hand operated slide gate, and one 12 ft wide stoplog bay. All the stoplog bays are also hand operated. The recommended plan (Plan 5A) is to modify the spillway by providing vertical lift gates at bay area #1 (14 ft wide) and at bay area #5 (14 ft wide). Sill elevations at these bay areas will remain the same at 1285.2 and opening of the gates would be allowed up to elevation 1302.0. The remaining four bay areas would remain the same as existing.

72. Of the various gate types available, the vertical lift gate lends itself most easily to modification of an existing stoplog structure. Lift gates have proven more economical for this span, than taintor gates. Therefore, reconversion to the original taintor gate design was not considered. The stoplog recess and sill will require modification to accomodate the lift gate. However, modification should be minimal, and most importantly, the piers are designed to withstand stoplog force reactions which are similar to the lift gate force reations. Hence, a major pier redesign will probably not be required. Pier space and clearances appear available to accomodate the necessary lift gate machinery.

73. To insure structural stability of the dam embankment and control structure, modifications and/or repairs are required to: the dam embankment; the soil-piling system supporting the piers in their capacity to shead loads; the deteriorating surfaces of the concrete control structure; and, the steel surfaces of the control structure and bridge. Although all

of the above items need to be investigated and addressed during future design studies, only the items which have a direct relation to work that would be required during implementation of the recommended plan are addressed below.

74. Assuming any resurfacing would be accomplished in conjunction with lift gate conversion, to simplify the demarcations, the gate conversion estimate will not include any concrete work. While recess modification is a major item, when viewed from a conversion standpoint, in all probability the stoplog recess would require maintenance resurfacing. The recess modifications become relatively minor when viewed from the resurfacing standpoint. Therefore, pier concrete resurfacing shall be considered a maintenance item, and costs for resurfacing will not be included in this report.

75. Stabilization design was not performed at this time for the control structure piers. A conservative construction cost of $30,000.00 per pier was developed from professional experience. The total construction cost estimate for soil-anchor stabilization of the control structure is $120,000.00.

76. As shown in the detailed cost estimate for the recommended plan (table 5), the total cost estimate of this alternative, including geotechnical considerations, is $1,121,800.00. The detailed cost estimate (for plan 5A) is also shown as plate 14 and detailed cost estimates for plans 5B and 5C are presented on plates 15 and 16, respectively.

Table 5 - Detailed Estimate of First Costs for Recommended Plan

Item	Unit	Quantity	Unit Cost	Total Estimated Cost
Cofferdam 2-gates				
a) upstream	JOB	LS	-	43,000
b) downstream	JOB	LS	-	8,100
Stabilize piers w/soil anchors	JOB	LS	-	122,400
Prepare gate openings	EA	2	4,100	8,200
14 x 17 vertical lift gate	EA	2	138,700	277,400
Electrical	JOB	LS	-	15,300
Geotechnical Considerations				255,300
Subtotal				$ 729,700
Contingencies (25%)				182,300
Total Construction				$ 912,000
Engineering & Design (15%+)				136,800
Supervision & Administration (8%+)				73,000
TOTAL PROJECT COST				$1,121,800

ECONOMIC ANALYSIS

77. Plan 5 is considered the least costly alternative of the seven plans for the spillway control and pier stabilization. This plan has three alternatives with preliminary cost estimates. Plan 5A is recommended because it has the lowest cost ($729,400). Addition of geotechnical considerations, common to all plans, brings the total cost for the recommended plan to $1,121,800.00. In addition to providing for five feet of freeboard, it provides for better and efficient operation of the control structure under normal flood conditions. If the required freeboard is not provided, there is a potential for the loss of the dam endangering downstream life and property and the benefits of the reservoir (flood control, navigation, water supply and recreation) are lost. A detailed economic analysis is not warranted as per paragraph 6a of ER 1130-2-417, dated 30 November 1980.

ENVIRONMENTAL CONSIDERATIONS

EXISTING CONDITIONS

Fish and Wildlife Resources

78. The habitats of the headwaters area are diverse and support an abundance of fish and wildlife. The forests, marshes and wetlands bordering and connecting many water bodies provide ideal habitat conditions for many species of migratory waterfowl and game fish. Forest communities are the dominant type of vegetation in the headwaters area and scattered bog and marsh communities exist in shallow bays and poorly drained areas but are not as abundant.

79. Winnibigoshish Lake lowland forest shoreline includes tree species such as American elm, green ash, northern red oak and paper birch. The shrub layer in this area is dominated by chokecherry, alder and dogwood. The more upland sites are dominated by paper birch, trembling aspen, ironwood and pine-mixed hardwood trees with hazelnut, honeysuckle and raspberry shrubs. Maple - basswood communities are situated away from the lake on high ground. Marsh communities are numerous.

80. Many of the animals around the headwaters lakes range over a wide area; others are more confined in their distribution. In all cases, a species is limited by environmental tolerances. Although the general land character of the lakes area was once primarily coniferous, numerous factors such as lumbering and forestry have reduced it to second growth forests of mixed deciduous and coniferous vegetation. This has impacted the ecosystem and resulted in the sharing of habitats by some forms of wildlife that have adapted to survival under a variety of conditions. Future studies will include inventory of threatened or endangered species in the project area, and coordination with the U.S. Fish and Wildlife Service.

81. Wildlife habitats in the forested vicinity of Winnibigoshish Lake include animals such as white tailed deer, moose, squirrel, chipmunk and shrew. Reptiles and amphibians such as frog, salamander and garter snake also inhabit the area.

82. The reservoir area supports a large variety of birds. These include great blue heron, hawks, blue jay, warblers, great horned owl and loon among several others.

83. The lakes support major populations of fish. Some of the more common species include northern pike, walleye, muskee, yellow perch, bass, and crappie. Shoreline erosion and wave action in the lakes have a tendency to create sandbars which may close off northern pike spawning marshes. Also, water levels can affect walleye incubation on offshore gravel slopes. Although eutrophication does not yet appear to have impacted fish populations, the prospect of increased nutrient levels requires monitoring.

84. The soils in the Winnibigoshish Lake area are generally coarse to medium textured forest soils formed from glacial outwash and comprised mostly of gravel or sandy gravel near the surface. Often these sands and gravels are overlain with fine sandy loams which become peat in depressions. They may be excessively drained soils and are subject to drought and wind erosion. The moisture prone soils along the shoreline, close to the water table tend to have a high mineral content.

Recreational Resources

85. The recreational facilities available in the headwaters area are numerous ranging from camping sites accessible only by backpacking to ultra modern facilities.

86. The Lake Winnibigoshish Recreation Area is sited on about 10 acres of land on the east bank of the Mississippi River immediately below the dam. Facilities available at the site include camping areas, picnic units, a canoe launch, a playground and a day use area.

Cultural Resources

87. A systematic survey for cultural resources has been carried out at Winnibigoshish Lake. A total of 53 archeological sites were located. Nearly all of them have been partially or completely disturbed or destroyed by inundation or shoreline erosion resulting from raising the water 8 to 12 feet above its natural level. There are no archeological sites within the public use areas. The construction of the dam and dam operator's residence destroyed parts of a habitation site and associated burial mounds. Material from the site indicates occupation by people of Sandy Lake and Blackduck cultural affiliations. The Winnibigoshish Dam is listed on the National Register of Historic Places. The Minnesota state historic preservation officer (SHPO) has stated that modifications to the dam will have to be reviewed in accordance with the procedures of the Advisory Council on Historic Preservation (letter dated 29 October 1984, Appendix A). Future studies will involve continuing coordination with the SHPO and Advisory Council (ACHP), so that adverse impacts may be avoided or mitigated.

POTENTIAL IMPACTS

88. The dam safety alternatives currently under consideration include: (1) Remove entire dam; (2) Raise and improve the existing dam embankments and dikes; (3) Construct a new additional spillway; (4) Widen the existing spillway; (5) Modify the spillway controls; (6) Perform extensive maintenance only; and (7) Accept existing condition, acquire inundated land downstream. Because detailed designs for these alternatives are not yet available, only potential impacts can be identified. Although Plan 5 is the recommended plan potential impacts will be identified for all the alternatives evaluated above.

Fish and Wildlife

89. Removal of the dam (Plan 1) would have a significant impact upon the fishery resources of Winnibigoshish Lake creating a shallower, more marshy lake than what currently exists. Raising the embankment and dikes (Plan 2) would have disturbance type impacts but no long term effects. Construction of a new spillway (Plan 3) would potentially impact upon the fish hatchery located below the dam as well as have disturbance type impacts associated with construction. Structural modifications at the control structure (Plans 2, 4-6) would have very minor construction type impacts such as localized turbidity impacts on water quality and localized ground disturbances. Purchasing lands downstream (Plan 7) could have beneficial impacts by preserving floodplain lands in a natural condition. The benefits would depend upon the type of lands purchased.

Recreation

90. Recreation facilities are located at the dam. Any construction in this area could affect these resources. The resources might therefore require replacement, or some form of compensation might be necessary.

Cultural

91. The recommended plan would affect the Winnibigoshish Dam, a property listed on the National Register of Historic Places. Further coordination with the SHPO and ACHP will be undertaken to define the extent of impacts to the dam, and to avoid or mitigate those impacts. The SHPO has stated that there will be no adverse impacts to shoreline archaeological sites as long as the frequency or amplitude of water level fluctuation is not increased (letter dated 29 October 1984, Appendix A).

FUTURE STUDIES

92. Future studies would include a detailed analysis of the alternatives and the selected plan. This analysis would cover vegetation, wildlife, cultural, recreation, social, and water resources. A number of evaluations must be conducted in the detailed design stage of the project for compliance with Executive Orders on wetland (EO 11990) and floodplains (EO 11988) and the Council on Environmental Quality Memorandum on prime and unique farmlands. In addition, an endangered species assessment must be prepared in compliance with the endangered Species Act, and a Section 404

(b)(1) evaluation may be needed to comply with the Clean Water Act. No additional cultural resource surveys are necessary for any project alternatives that include only Corps-owned land. However, if any alternatives are proposed that include land not currently owned in fee title by the Corps, additional surveys would be necessary to determine if any sites would be affected. Any sites located that may be affected by the proposed project must be tested to determine their significance. All significant sites that are listed on or eligible for inclusion on the National Register and that will be affected by the proposed project must be mitigated in accordance with the Advisory Council on Historic Preservation Regulations (36 CFR 800). Preparation of an environmental impact statement (EIS) or assessment and finding of no significant impact (FONSI) would proceed concurrently with work on the feature design memorandum.

SCHEDULE OF RECOMMENDED WORK

93. A proposed schedule for the work discussed is given below.

Milestone	No	Date
Reconnaissance Report (Revised)	38	April 1985
NCD Action	39	May 1985
OCE Approval	40	June 1985
Design Conference	41	Nov 1985
Draft GDM/NEPA	42	July 1986
NCD Action	43	September 1986
File Draft NEPA	44	October 1986
OCE Action	45	November 1986
Final GDM/NEPA	46	January 1987
File Final NEPA	47	March 1987
Complete Section 404	48	April 1987
Sign ROD/FONSI	49	June 1987
Approve Report	50	March 1987
Plans & Specifications to NCD	55	May 1987
NCD Action P&S	56	June 1987
Initiate Construction	59	August 1987
Complete Construction	60	September 1988

The estimated funding required for the above tasks is as follows:

FY 85	$30,000
FY 86	$82,140
FY 87	$195,460
FY 88	$844,200
Total =	$1,151,800

COST-SHARING AND LOCAL COPPERATION REQUIREMENTS

94. Guidelines for the method of cost-sharing for dam safety assurance work contained in ER 1130-2-417 state that specific and joint use costs are to be allocated using the same percentage that was used for construction expenditures. However, there was no cost-sharing arrangement made with non-Federal interests for the construction of Winnibigoshish Dam. For this reason and because of the fact that the only modifications required for dam safety at this site are those needed to upgrade the project features to follow current engineering standards; it is assumed that there will be no non-Federal cost-sharing for the recommended plan. This would hold true even if it is determined during the design memorandum report that additional lands, easements, rights-of-way and/or modifications are required to roads, bridges or utilities.

95. The Dam Safety Program provides for modification of completed Corps of Engineers dam projects which are potential safety hazards by current engineering standards. The program is intended to facilitate upgrading those project features related to dam safety in order to permit the project to function effectively and as originally intended.

96. For the proposed plan components to serve their intended purposes, local interests must comply with certain conditions of local cooperation. Prior to construction, they will have to furnish assurances satisfactory to the Secretary of the Army that they will:

a. Prescribe and enforce regulations to prevent obstructions or encroachments on channels, floodplain and floodway areas, and ponding areas, which would reduce their flood-carrying capacity or hinder the operation and maintenance of the project and/or compromise the level of protection provided by the project.

b. Regulate levee construction along the Mississippi River, to the full extent permitted by existing statutes, ordinances, regulations and rules, to assure that construction of levees does not significantly affect flood levels and/or potentially increase flood damages either upstream or downstream.

c. Inform affected interests of the limitations of the protection afforded by the project at least once a year.

d. Comply with the applicable provisions of the "Uniform Relocation Assistance and Property Acquisition Policies Act of 1970," Public Law 91-646, approved 2 January 1971, in the acquisition of any lands, easements, and rights-of-way for the construction and subsequent maintenance of the project, and inform affected persons of pertinent benefits, policies, and procedures in connection with the Act.

e. Regulate drainage activities in the watershed to assure that flood frequencies and discharges are not increased or that the effectiveness of the project is not adversely affected.

f. Publicize floodplain information and provide this information to zoning and other regulatory agencies for their guidance in preventing unwise future development in the floodplain. This information will also provide guidance in adopting regulations necessary to insure compatibility between future development and protection provided by the project.

g. Hold and save the United States free from damages that may result from construction and maintenance of the project, not including damages which are due to the fault or negligence of the United States or its contractor.

h. Comply with Section 601, Title VI of the Civil Rights Act of 1964 (Public Law 88-352) and Department of Defense Directive 5500.11, published in Part 300 of the Title 32, Code of Federal Regulations, in connection with the construction and operation of the project.

RECOMMENDATION

97. The recommended plan involves modification of the spillway by providing vertical lift gates at bay areas #1 and #5 as well as pier stabilization. Several geotechnical recommendations are also included as part of the overall plan. Specifically, these recommendations involve widening the top width of the existing embankment and flattening both upstream and downstream slopes. Additionally, the existing bituminous roadway is recommended for removal with the underlying embankment to be thoroughly compacted.

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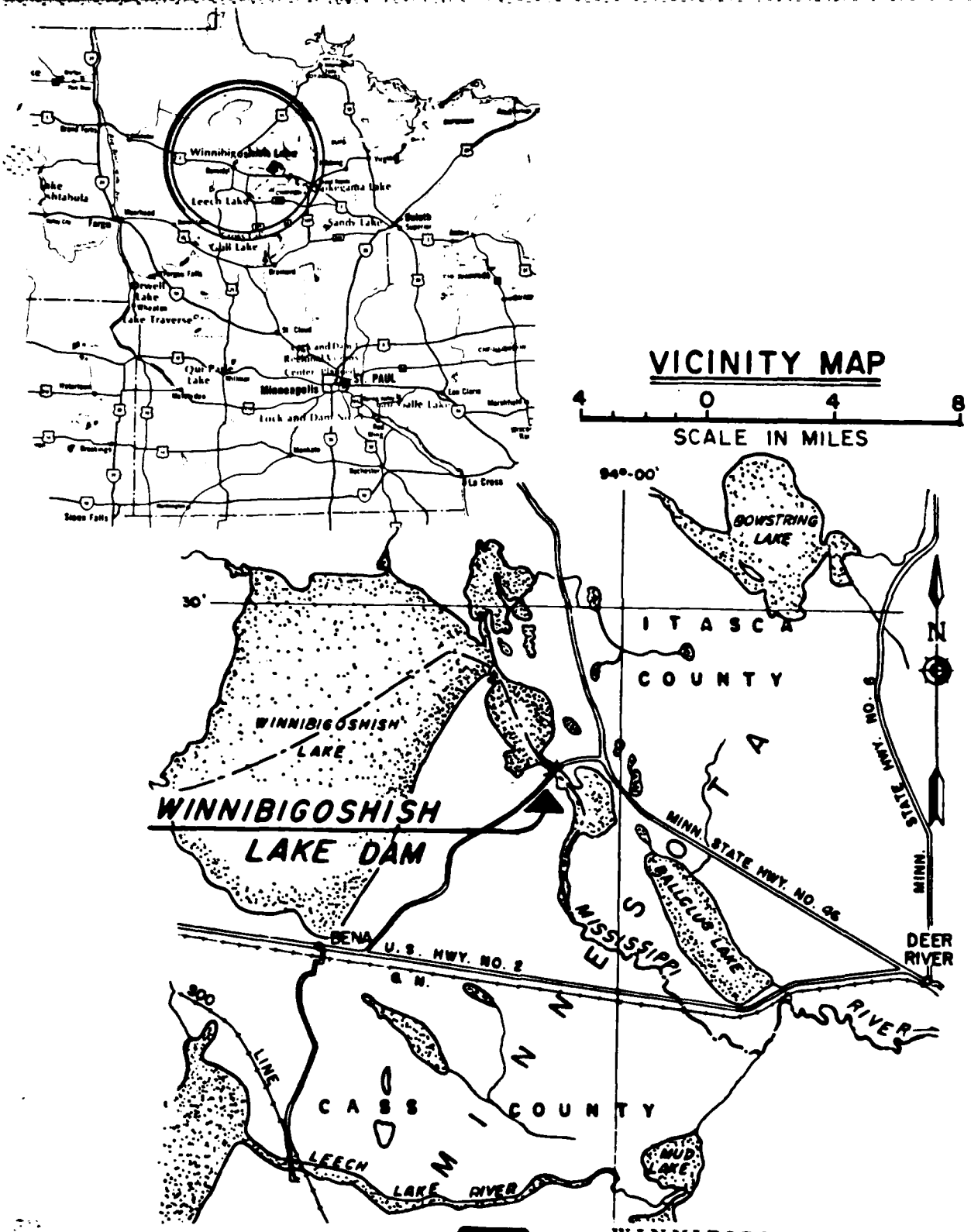


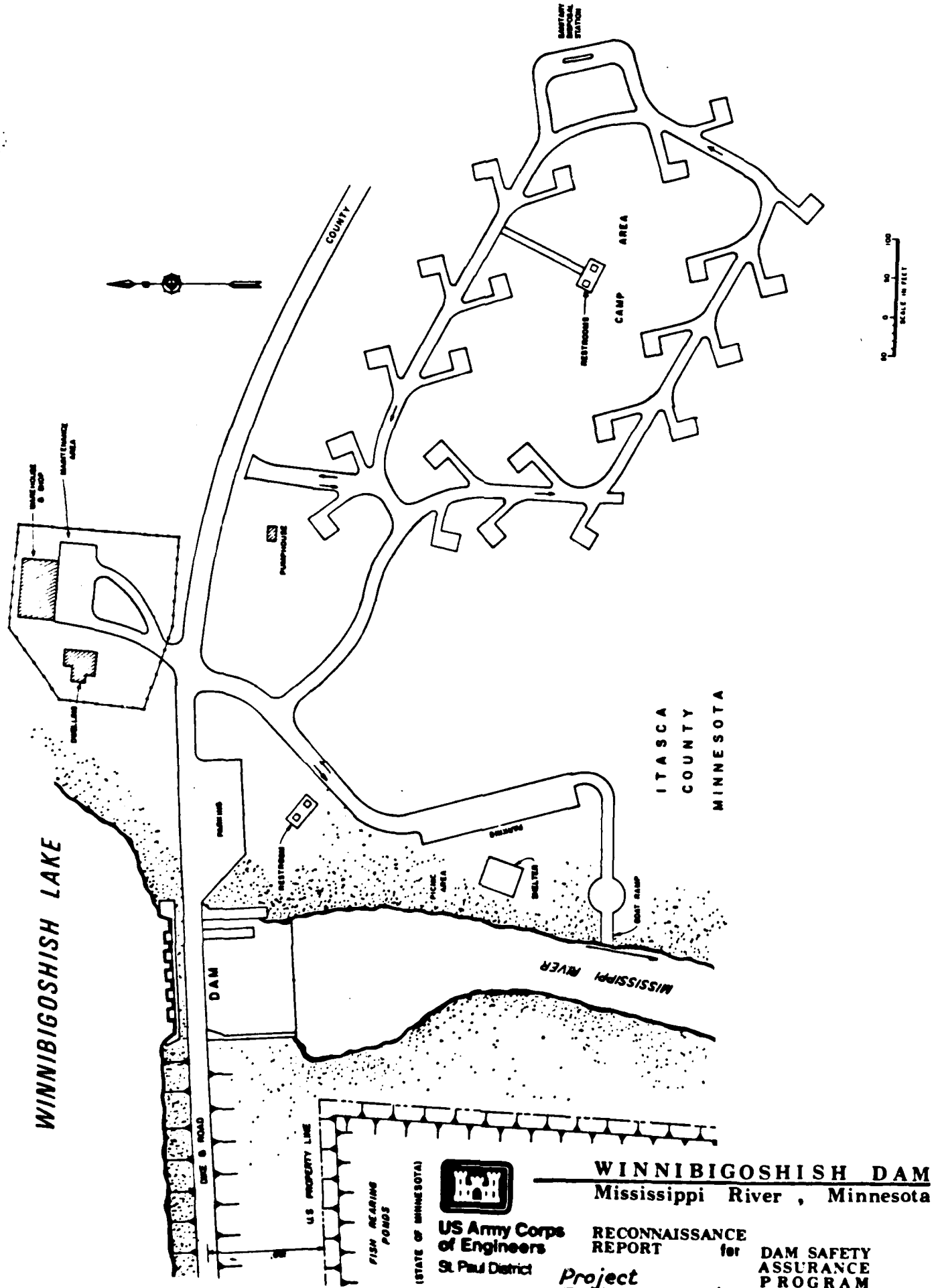
WINNIBIGOSHISH DAM
Mississippi River , Minnesota

US Army Corps of Engineers
St. Paul District

RECONNAISSANCE REPORT for DAM SAFETY ASSURANCE PROGRAM

Location Map

plate 1.



US Army Corps of Engineers
St Paul District
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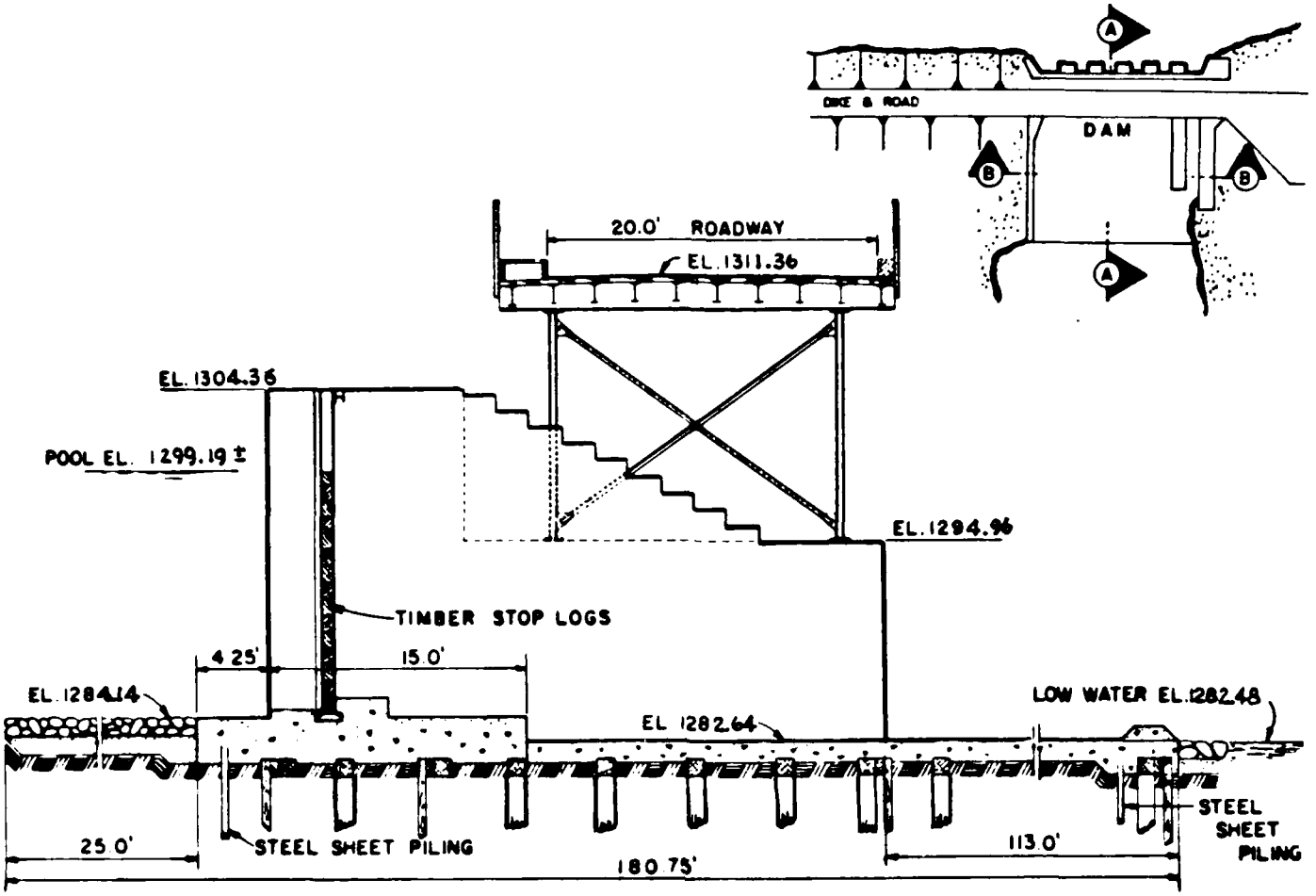
WINNIBIGOSHISH DAM
Mississippi River , Minnesota

RECONNAISSANCE REPORT for DAM SAFETY ASSURANCE PROGRAM

Project Features · plan view

plate 2.

WINNIBIGOSHISH LAKE



SECTION A-A

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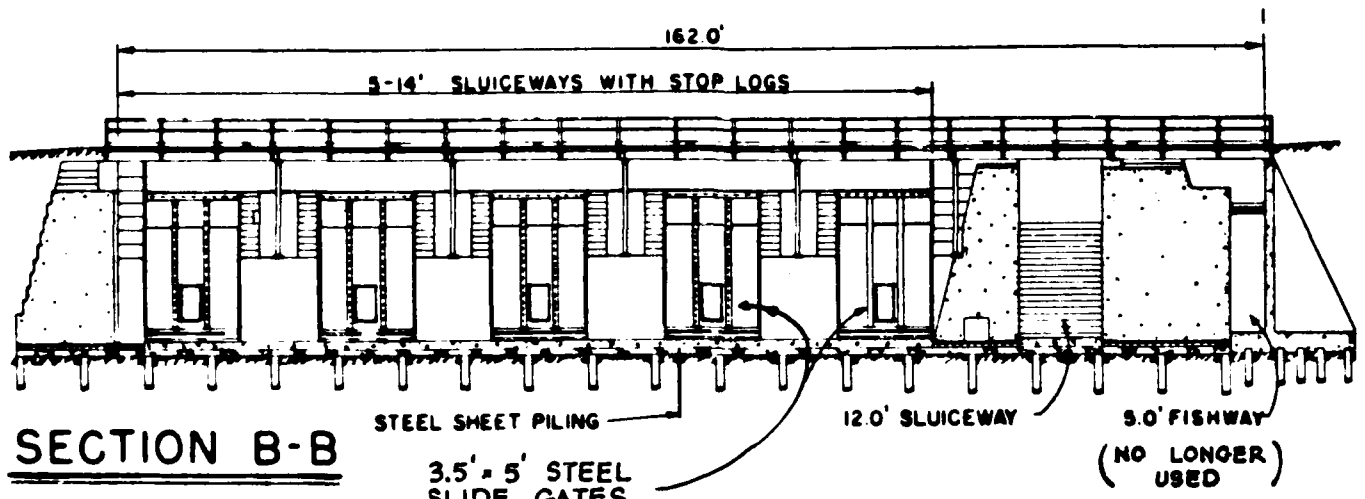
SCALE IN FEET



SECTION B-B

10 0 10 20 30 40
SCALE IN FEET

WINNIBIGOSHISH DAM

Mississippi River , Minnesota

US Army Corps of Engineers
St Paul District
FEB 1984

RECONNAISSANCE REPORT for DAM SAFETY ASSURANCE PROGRAM

Project Features . Control Structures

plate 3.

LAKE WINNIBIGOSHISH DAM — SHEET 4 OF 4

PROJECT
GEOTECHNICAL RECOMMENDATIONS (PLANS 5A, 5B, 5C)

ITEM NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	
1	EXCAVATION				
	REMOVE EXISTING ROAD	650	CY	4.00	2,6[illegible]
2	COMPACT EXISTING EMBANKMENT	LS	JOB		3,500
3	BITUMINOUS FOR NEW ROADWAY	210	CY	75.00	15,750
4	RCKL RIPRAP MATERIAL	400	CY	15.00	6,000
5	G RIPRAP	2100	CY	25.00	52,500
6	BEDDING	1000	CY	18.00	18,000
7	REMOVE EXISTING GROUTED RIPRAP	1400	CY	4.00	5,600
8	STA SPALL	1300	CY	2.00	2,600
9	TOPSOIL	1150	CY	2.50	2,875
10	INSTALL 6' MH	3	EA	8000	24,000
11	INSTALL 6' HEADWALL	1	EA	10,000	10,000
12	INSTALL 24" ϕ PVC	800	LF	30.00	24,000
13	FILL OF TRENCH	3100	CY	400	12,400
14	COMPACTED EMBANKMENT FILL	13000	CY	1.75	22,750
15	EXTEND CONCRETE WINGWALL	LS	JOB	1	50,000
16	SEEDING	1.5	AC.	1,800	2,700
	SUBTOTAL				$255,275
	CONTINGENCIES	25%			63,725
	TOTAL				$319,000
	E ϕ D	15%			47,900
	S ϕ A	8%			25,500
	TOTAL				$ 392,400

COST ESTIMATE
GEOTECHNICAL RECOMMENDATIONS

DNO FORM APR 67 1738 SUPERSEDES DNO FORM 1738, 1 APR 64, WHICH IS OBSOLETE

Plate 17

LAKE WINNIBIGOSHISH DAM — SHEET 3 OF 4

PROJECT
SPILLWAY MODIFICATION/PIER STABILIZATION (PLAN 5C)

ITEM NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	
1	CONCRETE WALL & GATES				
	a) UPSTREAM	LS	JOB		128,400
	b) DOWNSTREAM	LS	JOB		24,400
2	STABILIZE PIERS W/ SOIL ANCHORS	LS	JOB		122,700
3	PREFACE GATE OPENINGS	6	EA.	4,100	24,600
4	14 x 17 VERTICAL LIFT GATE	5	EA.	138,700	693,500
5	SEAL 12 x 17 OPENING W/ CONCRETE PLUG	12	EA.	360	4,300
6	ELECTRICAL	LS	JOB		15,300
	SUBTOTAL				$ 4,012,900
	CONTINGENCIES	25%			253,100
	TOTAL CONSTRUCTION COST				$ 1,266,000
	E&D	15%			189,900
	S&A	8%			101,300
	TOTAL PROJECT COST				$ 1,557,200
	ENR INDEX 4181				

COST ESTIMATE
PLAN 5C

ENG FORM APR 81, 1738 PREVIOUS ENG FORM 1738 I APR 74, WHICH IS OBSOLETE

Plate 16

LAKE WILLIBIGOND - LAKE

SHEET 2 OF 4

PROJECT
SPILLWAY MODIFICATION/PIER STABILIZATION (PLAN 5B)

ITEM NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	
1	COFFERDAM 2 GATES				
	a) UPSTREAM	LS	JOB		43,000
	b DOWNSTREAM	LS	JOB		8,[illegible]
2	STABILIZE PIERS W/				
	SOIL ANCHORS	LS	JOB		122,400
3	FLEXIBLE GATE OPENINGS	2	EA	4,100	9,[illegible]
4	14 X 17 VERTICAL LIFT GATE	2	EA	138,700	277,400
5	MOTOR MOUNT FOR				
	3½ X 5' SLIDE GATE	3	EA	5,100	15,300
6	ELECTRICAL	LS	JOB		19,[illegible]
	SUBTOTAL				$ 489,700
	CONTINGENCIES	25%			122,300
	TOTAL CONSTRUCTION COST				$ 612,000
	E & D	15%			91,800
	S & A	8%			49,000
	TOTAL PROJECT COST				$ [illegible]
	ENR INDEX 4181				

COST ESTIMATE
PLAN 5B

DD FORM 1738, APR 81 PREVIOUS DD FORM 1738, 1 APR 74, WHICH IS OBSOLETE

Plate 15

LAKE WILLIBIGOSHISH DAM — SHEET 1 OF 4

PROJECT
SPILLWAY MODIFICATION / PIER STABILIZATION (PLAN 5A)

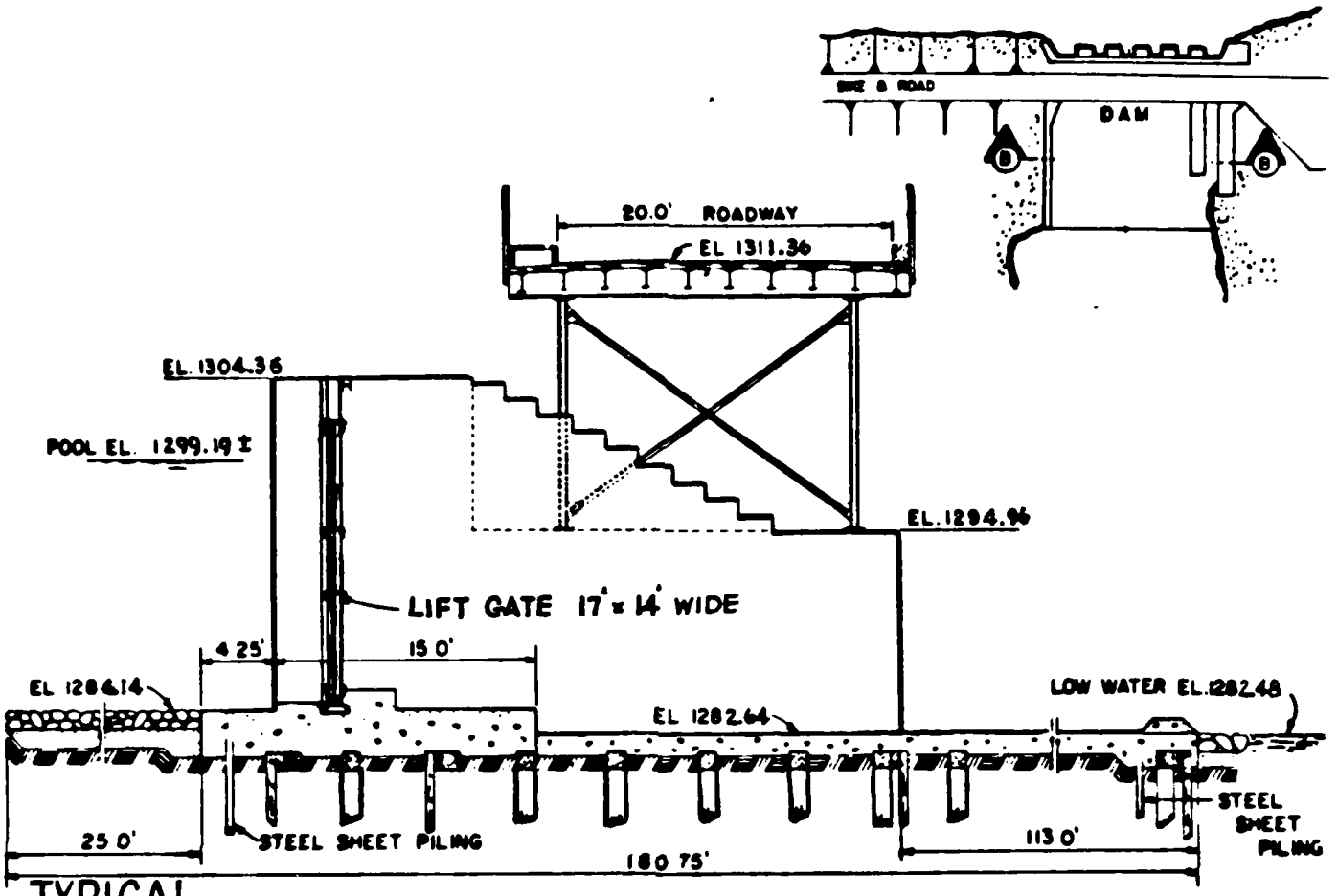
ITEM NO	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	
1	COFFERDAM 2 GATES				
	a) UPSTREAM	LS	JOB		43,000
	b) DOWNSTREAM	LS	JOB		8,100
2	STABILIZE PIERS W/ SOIL ANCHORS	LS	JOB		125,400
3	PREPARE GATE OPENINGS	2	EA	4,100	8,200
4	14 X 17 VERTICAL LIFT GATE	2	EA	138,700	277,400
5	ELECTRICAL	LS	JOB		15,300
	SUBTOTAL				$ 474,400
	CONTINGENCIES	25%			118,600
	TOTAL CONSTRUCTION COST				$ 593,000
	E & L	15%			89,000
	S & A	8%			47,400
	TOTAL PROJECT COST				$ 729,400
	ENR. INDEX 4181				

COST ESTIMATE
PLAN 5A

DD FORM 1738 (OUTDATED DD FORM 1738, 1 APR 64, WHICH IS OBSOLETE)

Plate 14

WINNIBIGOSHISH LAKE



TYPICAL SECTION

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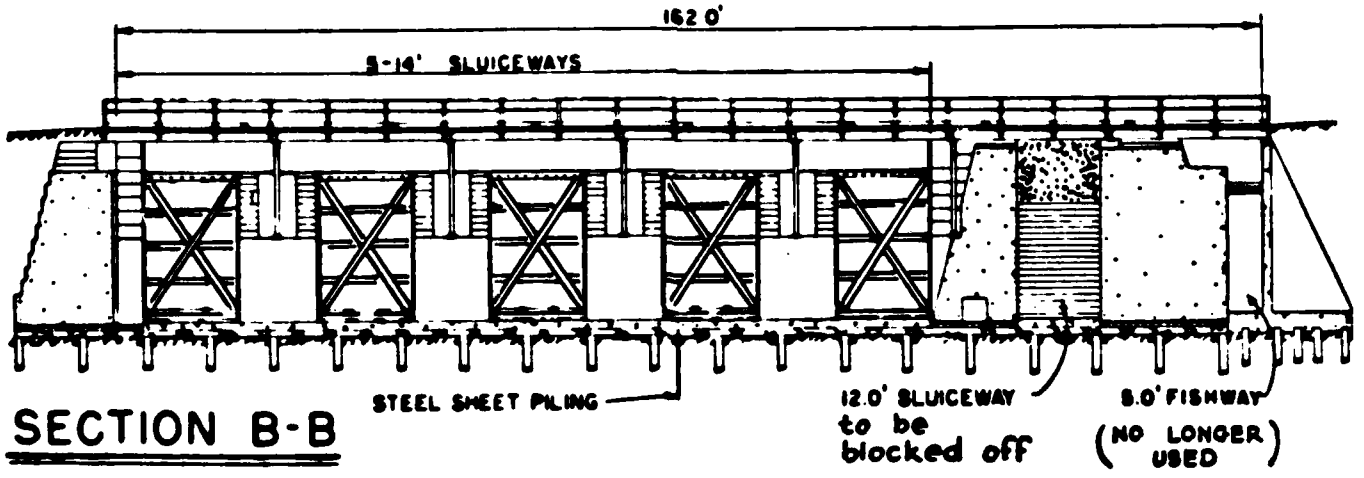
SCALE IN FEET

• Convert bay areas 1, 2, 3, 4 & 5 to LIFT GATES



SECTION B-B

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SCALE IN FEET

WINNIBIGOSHISH DAM
Mississippi River , Minnesota

US Army Corps of Engineers
St Paul District
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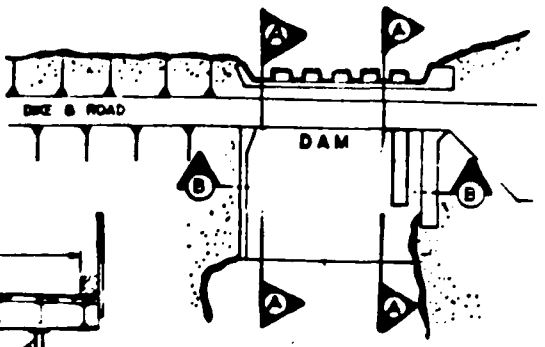
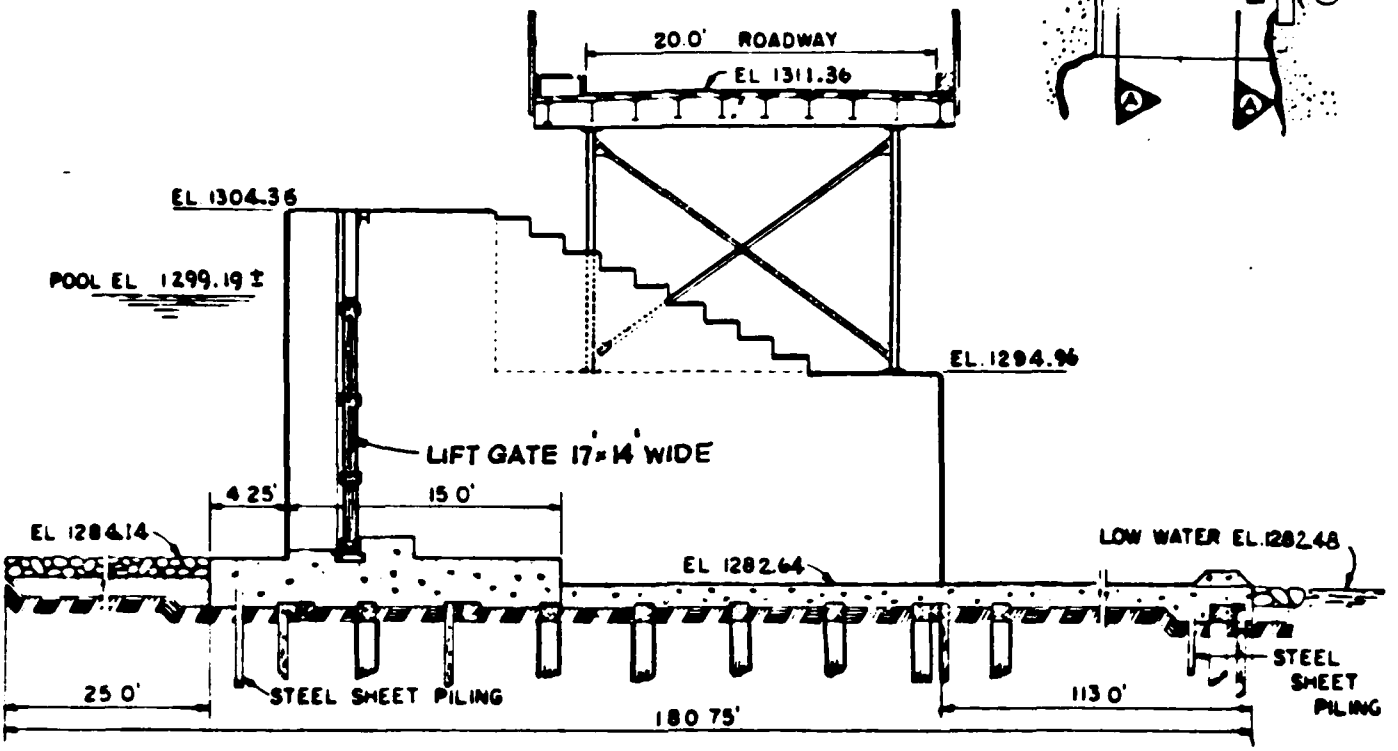
RECONNAISSANCE REPORT for *Project Features.* PLAN 5C

DAM SAFETY ASSURANCE PROGRAM

plate 13.

WINNIBIGOSHISH LAKE





SECTION A-A

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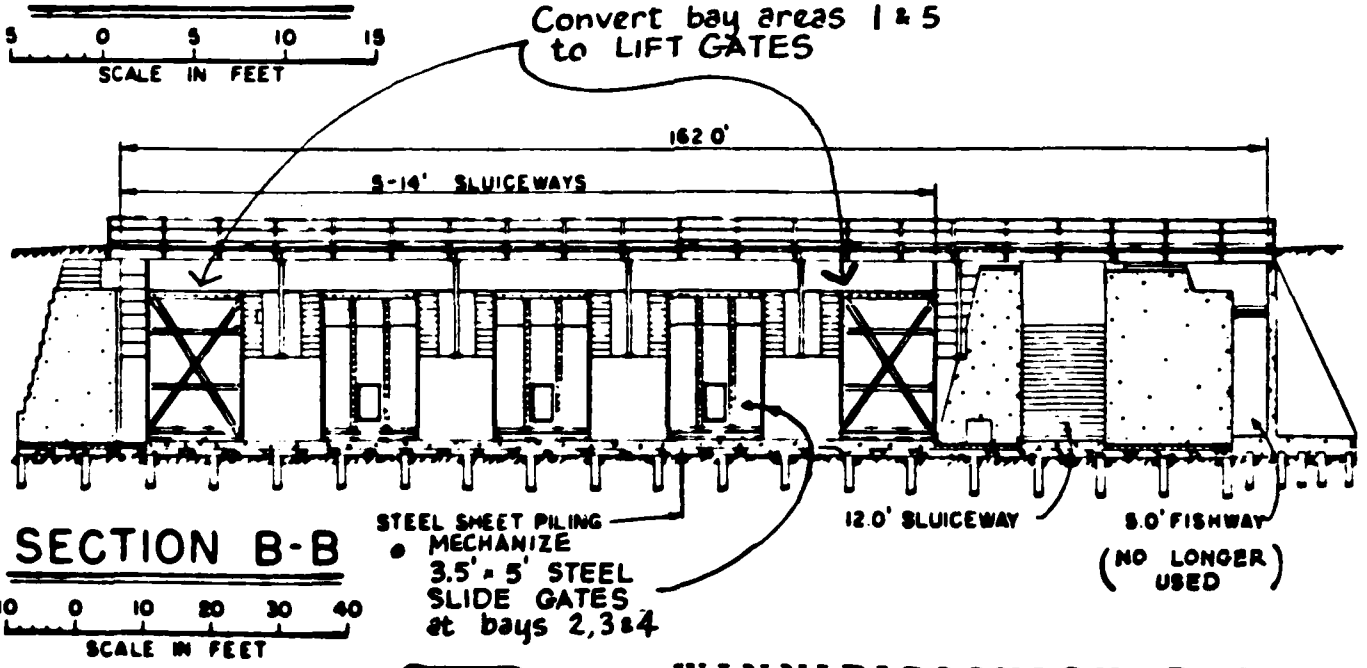

SECTION B-B

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SCALE IN FEET

WINNIBIGOSHISH DAM
Mississippi River , Minnesota

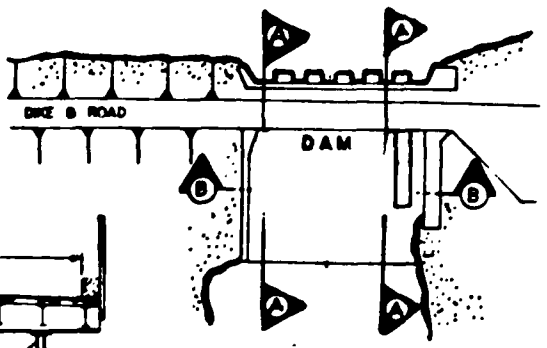
US Army Corps of Engineers
St Paul District
FEB 1984

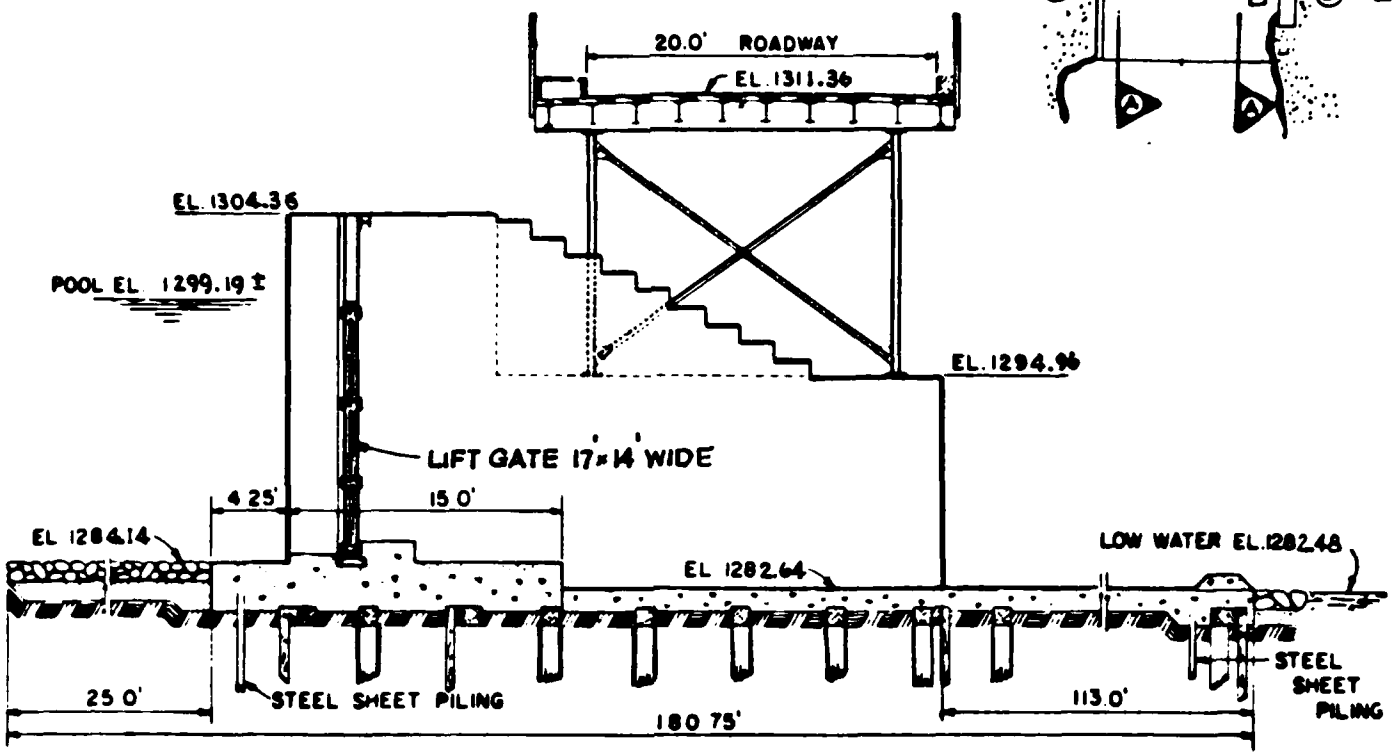
RECONNAISSANCE REPORT for DAM SAFETY ASSURANCE PROGRAM

Project Features
PLAN 5B

plate 12.

WINNIBIGOSHISH LAKE





SECTION A-A

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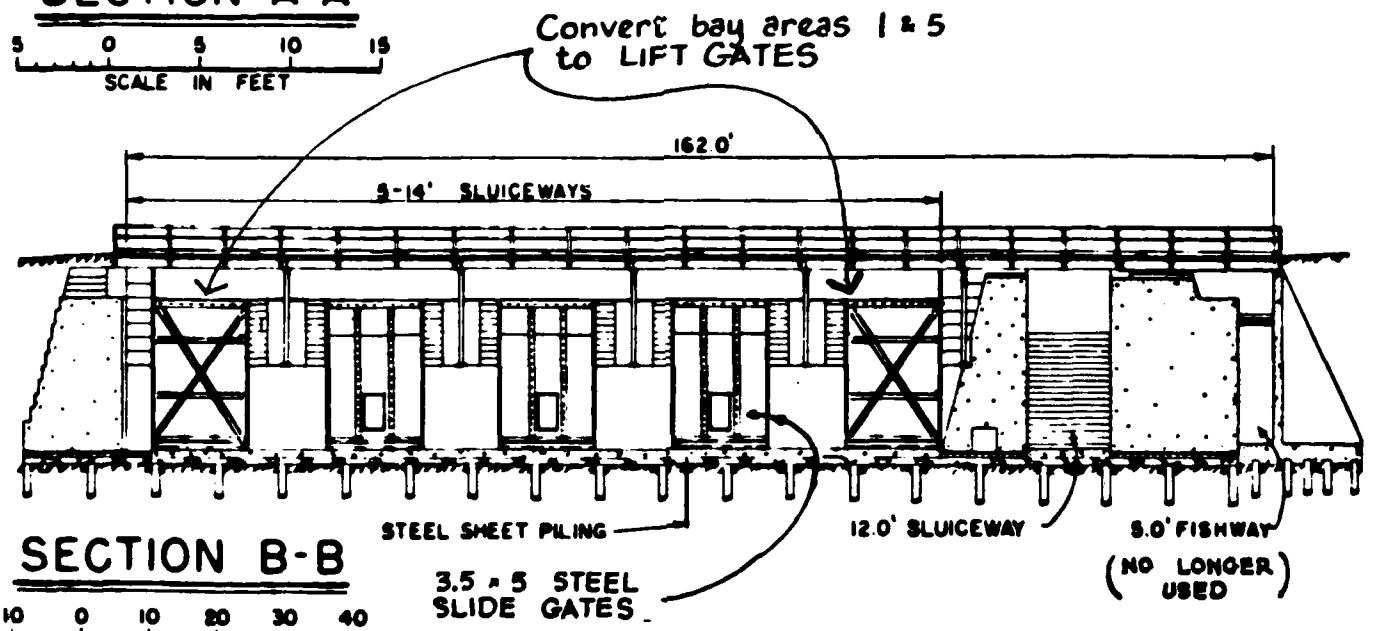

SECTION B-B

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SCALE IN FEET

WINNIBIGOSHISH DAM
Mississippi River , Minnesota

US Army Corps of Engineers
St Paul District
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RECONNAISSANCE REPORT for DAM SAFETY ASSURANCE PROGRAM

Project Features
PLAN 5A - Recommended Plan

plate II.

Boring Logs

plate 10.

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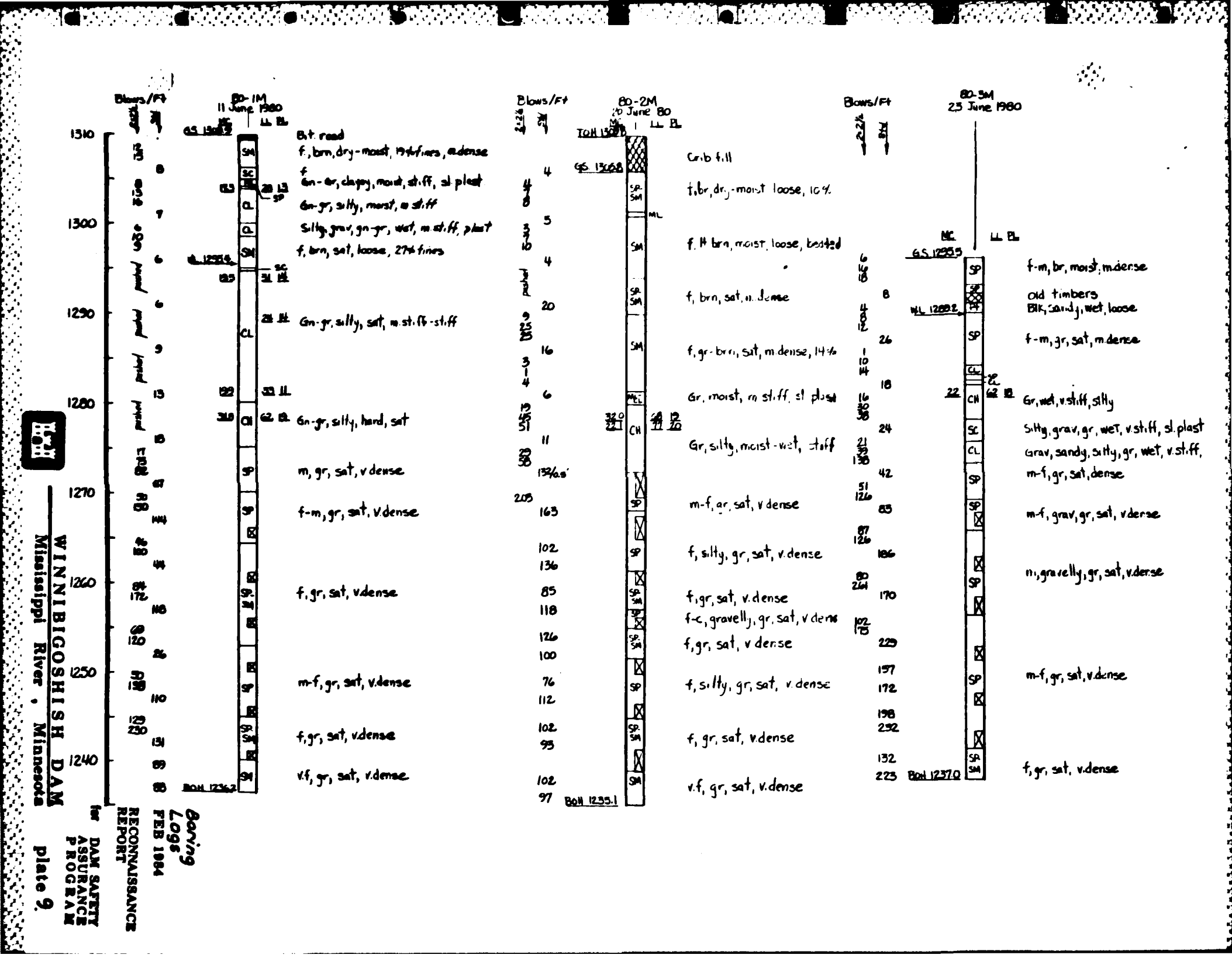
RECONNAISSANCE REPORT

for DAM SAFETY ASSURANCE PROGRAM

WINNIBIGOSHISH DAM

Mississippi River , Minnesota



WINNIBIGOSHISH DAM

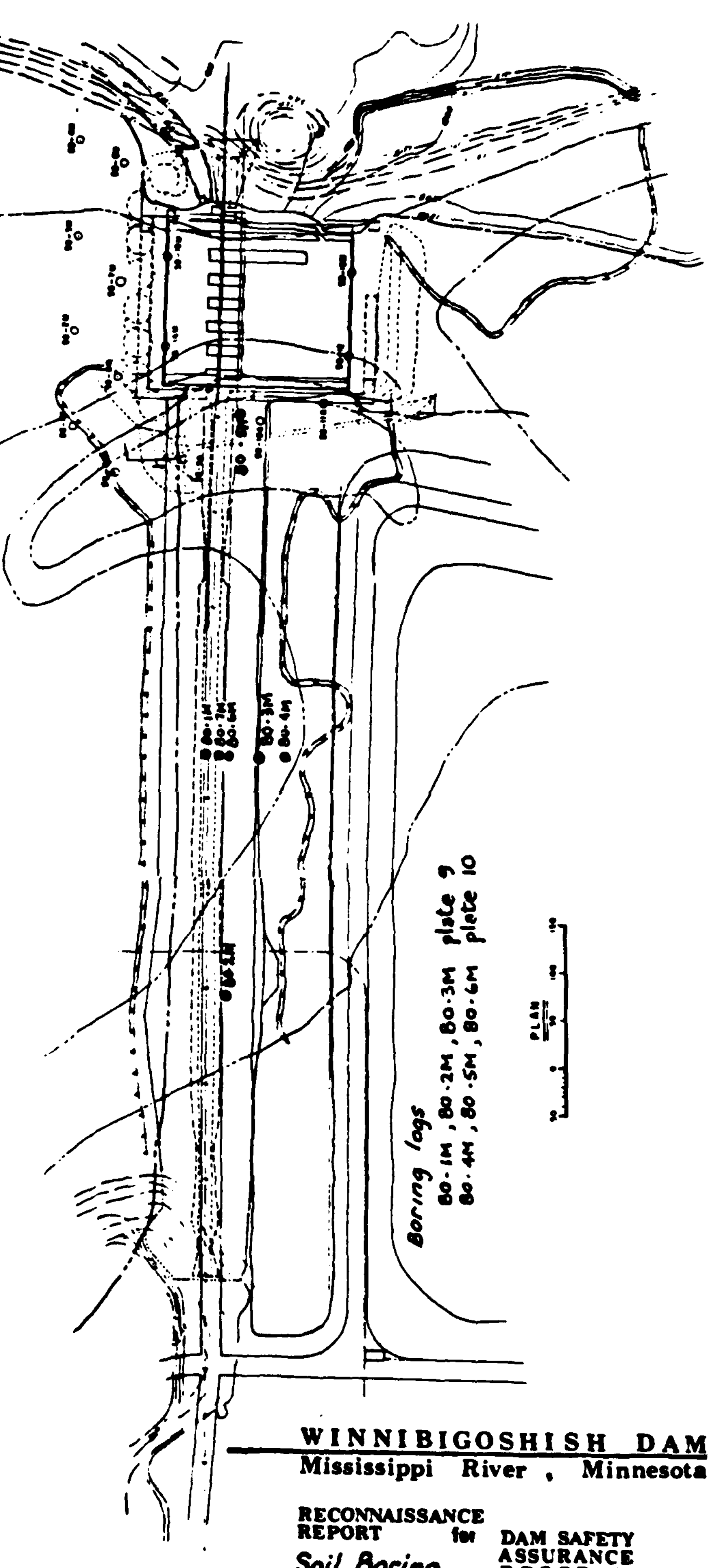
Mississippi River • Minnesota

for DAM SAFETY ASSURANCE PROGRAM

RECONNAISSANCE REPORT

Boring Logs FEB 1984

plate 9.



Notes

1. Screened data obtained from chief of engineers reports, record drawings & 1883-1884 progress drawings.
2. Structure shows reconstruction in 1900, 1912, 1934, 1958 & 1964.
3. Existing condition based on May 1978 surveys

WINNIBIGOSHISH DAM
Mississippi River, Minnesota

RECONNAISSANCE REPORT for DAM SAFETY ASSURANCE PROGRAM

Soil Boring Locations

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plate 8

WINNIBIGOSHISH DAM
Mississippi River , Minnesota

S Army Corps
of Engineers
St Paul District

RECONNAISSANCE
REPORT for DAM SAFETY
ASSURANCE
PROGRAM

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3.5' x 5.0'
SLIDE GATE

plate 7.

WINNIBIGOSHISH DAM
Mississippi River , Minnesota

US Army Corps of Engineers
St Paul District

RECONNAISSANCE REPORT for DAM SAFETY ASSURANCE PROGRAM

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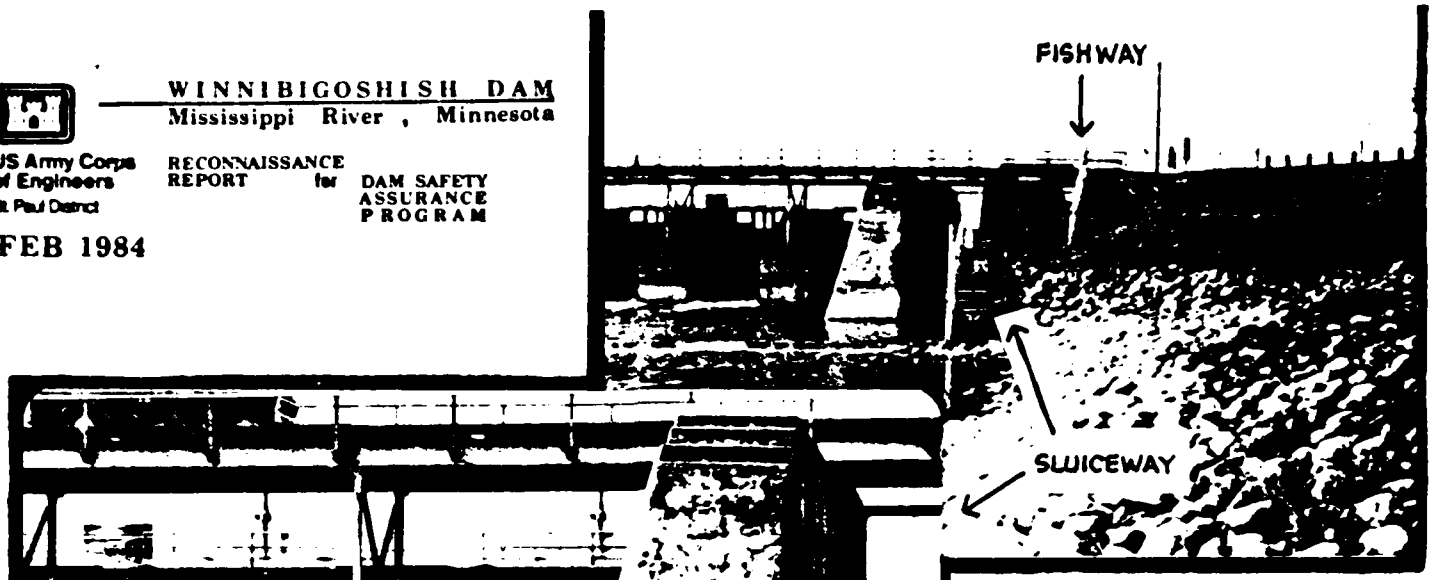
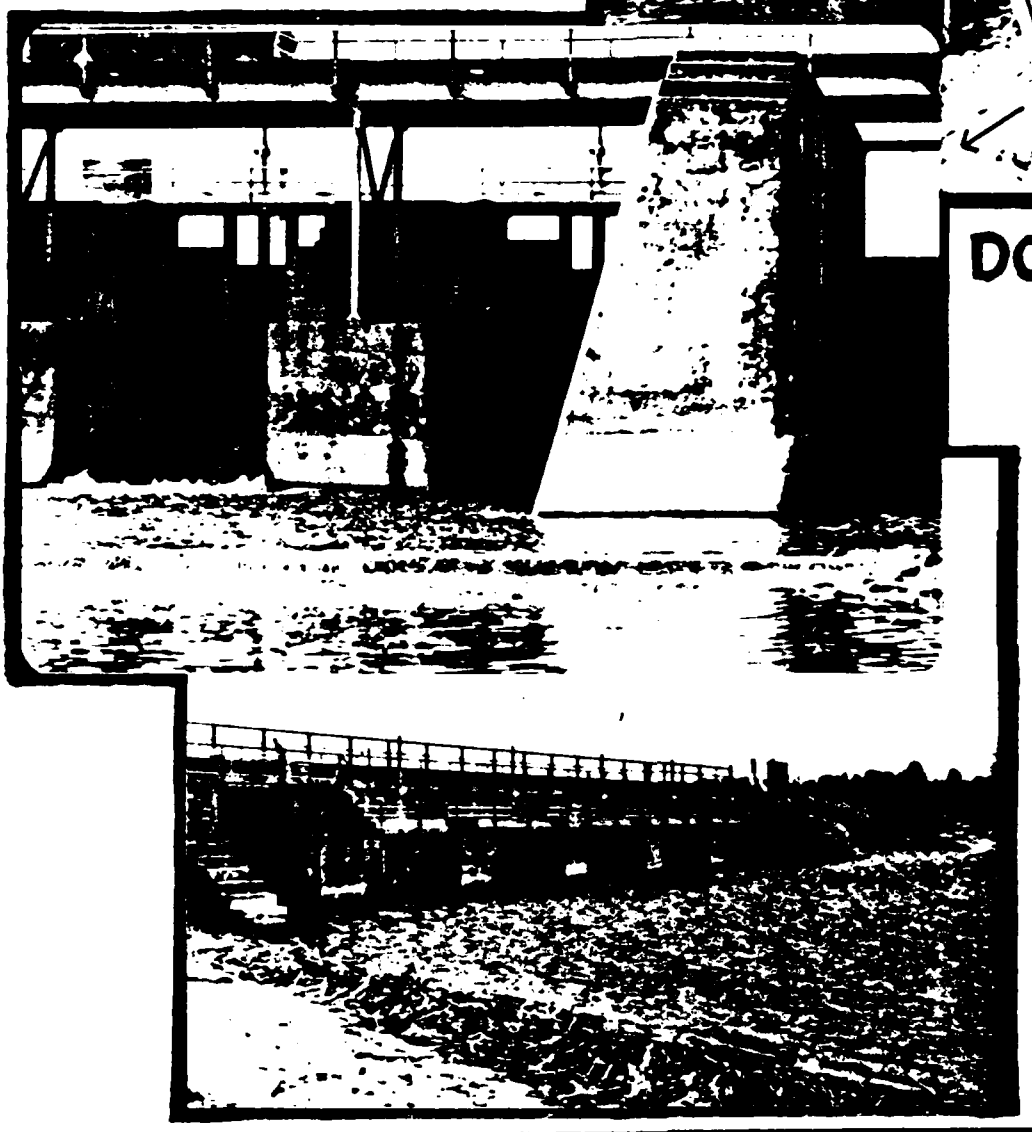
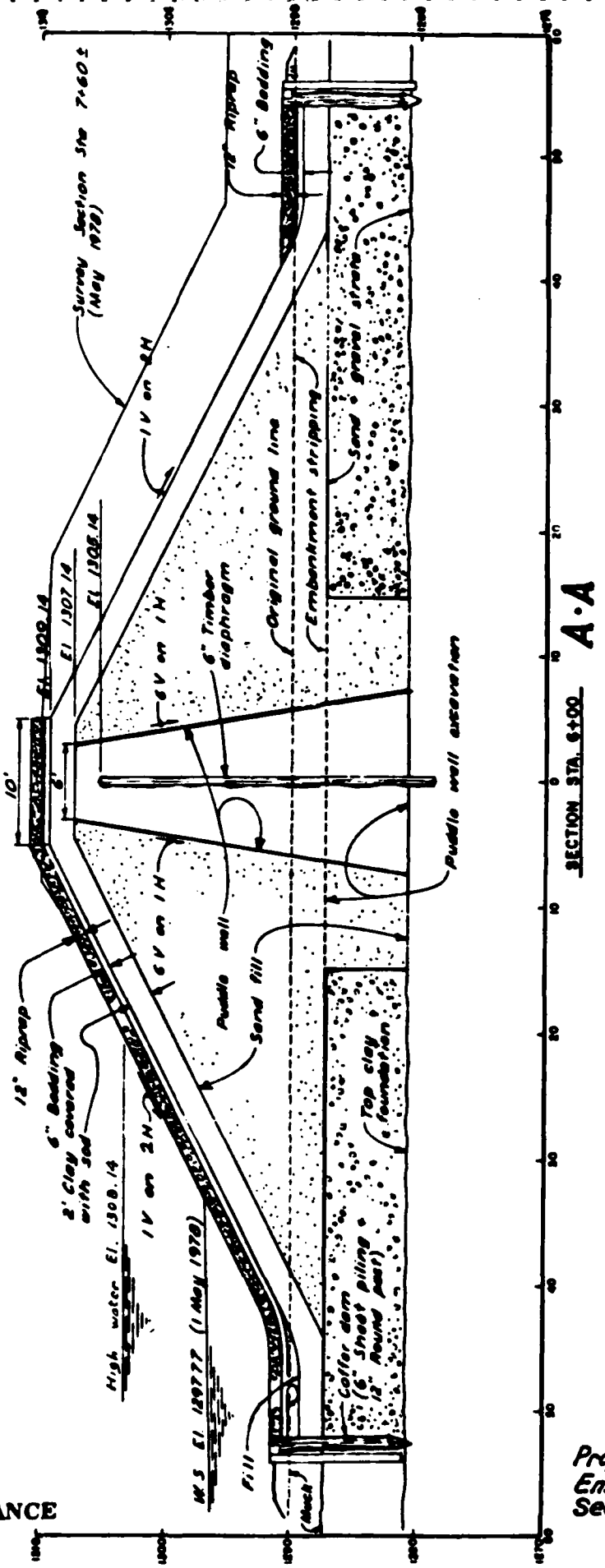


DOWNSTREAM SIDE



UPSTREAM SIDE

plate 6.



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WINNIBIGOSHISH DAM

Mississippi River , Minnesota

DAM SAFETY
ASSURANCE
PROGRAM

plate 5.

Project Features.
Embankment Profile

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RECONNAISSANCE REPORT for

DAM SAFETY ASSURANCE PROGRAM

WINNIBIGOSHISH DAM
Mississippi River , Minnesota

plate 4.

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